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Final Report

Groundwater Resources and Water Quality of Detrital and Hualapai Basins, Mohave County, Arizona

October 1982

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Final Report

GROUNDWATER RESOURCES AND WATER QUALITY OF DETRITAL AND HUALAPAI BASINS, MOHAVE COUNTY, ARIZONA

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Prepared for
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Denver, Colorado

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Chapter I

SUMMARY AND CONCLUSIONS

The scope of this investigation involves collecting, tabulating and interpreting all available hydrogeologic data for the Detrital and Hualapai groundwater basins of northwestern Arizona. The objective of the study is to characterize the groundwater flow system and make a limited water quality analysis in order to provide the U.S. Bureau of Land Management (BLM) with data for water resources planning and development. Because recent groundwater studies (Gillespie and Bentley, 1971; Remick, 1981) have been done in the Hualapai basin but not in the Detrital basin, emphasis was placed primarily on collecting and analyzing new data for the Detrital basin. Secondary emphasis was placed on updating and analyzing available data for the Hualapai basin.

A field investigation was carried out during March, April and May 1982, during which 120 wells and 14 springs were visited by Geo/Resource Consultants (GRC) personnel. Data collected at the sites included land elevations, water levels and discharge rates. Samples for water quality analysis were taken at selected sites.

The study area includes Detrital Valley, Hualapai Valley and the northern end of Sacramento Valley. The major mountain ranges bounding the valleys are the Black Mountains, Cerbat Mountains, White Hills and Grand Wash Cliffs.

Surface and groundwater drainage in Detrital Valley flows north toward the Colorado River at Lake Mead. Surface and groundwater drainage in the Sacramento Valley flows south and then west, also to the Colorado River. Hualapai Valley is a basin of closed surface drainage. Red Lake playa marks the lowest point of surface drainage in that valley. Nevertheless, groundwater exits the Hualapai basin both to the north and to

the southeast. Most of the groundwater flows north to the Colorado River at Lake Mead. A small portion of the groundwater exits the basin to the southeast, near the town of Hackberry, and flows toward Big Sandy Valley.

Essentially all of the streams in the study area are ephemeral. Stream flow is generated in the mountains in response to summer and winter storms. However, surface flow rarely reaches the central parts of the valleys because most of it is lost to infiltration and evapotranspiration on the upper and middle portions of the alluvial fans. This infiltration of streamflow on the alluvial fans is the primary source of recharge to groundwater beneath the valleys.

The only major community in the study area is the City of Kingman. Groundwater is the main source of water in the study area, and it is used principally for the municipal supply for Kingman and for irrigation in the southern Hualapai Valley. Groundwater is also used for municipal supplies at smaller communities, stockwatering, domestic supplies and small industry.

With respect to geology, most of the study area lies within the Basin and Range province, although the Grand Wash Cliffs on the eastern side of the study area form the edge of the Colorado Plateau province. The mountain ranges in the study area are tilted fault blocks flanked by north-striking normal faults. The valleys are the surface expressions of the intermontane basins formed between the tilted fault blocks. The mountains consist of Precambrian igneous and metamorphic rocks overlain by two volcanic rock units, called older and younger volcanics. In addition, Paleozoic sedimentary rocks cap the Grand Wash Cliffs. The basins are filled with younger volcanic flows, clastic sediments and evaporite deposits. The clastic sediments are divided into older, intermediate and younger alluvium. The older alluvium is interbedded with both the younger volcanics and evaporite deposits. Data suggest that

basin fill beneath the Hualapai Valley is more than 10,000 feet thick. Basin fill beneath Detrital Valley is probably at least 1,000 feet thick.

The Red Lake Salt body beneath the middle of Hualapai Valley may be on the order of twelve miles long, five miles wide, and two miles thick. The Detrital Valley salt body extends over several square miles beneath northern Detrital Valley, straddling the project area boundary. This salt body attains a maximum thickness of 715 feet. The hydrogeologic significance of large salt bodies is three-fold. First, because salt is relatively impermeable, a large salt body in a groundwater basin may impede groundwater flow substantially. Second, the presence of large volumes of salt beneath the water table is likely to have a deleterious effect on groundwater quality. Third, because the salt bodies are potential targets for exploitation, their presence has generated a great deal of test data, which have enhanced present understanding of the groundwater flow system. Furthermore, if the salt bodies are exploited in the future, the development would probably include industrial use of groundwater pumped from the alluvial basins.

The older alluvium, which underlies the valleys, is the main aquifer in the study area. Secondarily, the younger volcanic rocks are the most important aquifer in the mountain areas. The younger volcanics yield moderate amounts of water, through fractures and interbedded agglomerate and gravel, to wells near Kingman.

All of the hydrogeologic data collected and compiled by GRC are incorporated into a hydrogeologic map, which depicts our interpretation of the groundwater flow system throughout the study area. Beneath Detrital Valley, hydraulic gradients range from .001 to .044 foot per foot. The depth to water ranges from approximately 40 to 800 feet. Well yields in Detrital Valley range from about ten to 130 gallons per minute (gpm). The greatest concentration of the higher producing wells

occurs near Dolan Springs. We estimate that the total average annual consumption of groundwater in Detrital Valley is probably less than 500 acre-feet per year (af/yr). With regard to changing water levels with time, we assume that Detrital Valley groundwater levels are at approximately steady-state. On the basis of computations using Darcy's Law, we conclude that the minimum rate of groundwater outflow from Detrital Valley is on the order of 2,100 to 3,400 af/yr. As the result of a water balance, we estimate the minimum annual groundwater recharge to Detrital Valley to be approximately 2,600 to 3,900 af/yr.

The groundwater flow system in northern Sacramento Valley is complex. The presence and location of the Cerbat Mountain block range-front fault in this area is suggested by both geologic and hydrologic data. A secondary fault east of the main one is also postulated. Tennessee Wash Well, which is owned by the BLM, is dry probably because of its spatial position between these two apparent faults. Discrepancies in water levels in several wells drilled deep into alluvium in the northern end of Sacramento Valley suggest the presence of confining layers at depth. Most of the groundwater pumped from the northern end of Sacramento Valley is used as the municipal supply for the town of Chloride.

Beneath Hualapai Valley, hydraulic gradients range from .001 to .023 foot per foot. The depth to water in the main Hualapai basin ranges from approximately 300 to 900 feet. In the Truxton Wash-Hackberry area, the depth to water ranges from approximately 20 to 600 feet. Well yields in the Hualapai basin range from ten gpm for domestic wells to 1600 gpm for irrigation and municipal wells. The only area in the Hualapai basin with major groundwater level declines is the Truxton Wash-Hackberry area. The water level decline in this area ranges from about 20 to 75 feet from the early 1940's to 1980.

The following Hualapai Valley data are quoted from several different investigators. The groundwater consumption has

increased from less than 500 af/yr in 1960 to 6,000 af/yr in 1980. The estimated hydraulic conductivity ranges from 60 to 90 gallons per day per square foot, and estimates of aquifer transmissivity range from 22,000 to 44,000 gallons per day per foot. Another source indicates that transmissivity values near Red Lake range from 2,100 to 27,000 gallons per day per foot. One source estimates that the total subsurface outflow from the Hualapai basin is 5,000 af/yr, and the average annual recharge to the system is about the same. An alternative source indicates an average subsurface outflow of 2,400 to 3,800 af/yr and an average annual recharge rate of 8,000 to 12,000 af/yr. We believe that the latter estimate of average annual recharge is more reasonable.

In the younger volcanics near Kingman, well data suggest the presence of a northwest-striking barrier to groundwater flow, possibly a fault. North of the barrier groundwater flows southeastward, possibly through an interbed of agglomerate or gravel in the volcanic strata. In wells south of the barrier, water levels are about 300 feet lower than those in wells just north of the barrier.

In the mountain areas, groundwater occurs in fractured and weathered zones of the Precambrian igneous and metamorphic rocks, fractures and solution channels in the Paleozoic sedimentry rocks, and fractures and tuff beds in the volcanic rocks. The distribution of groundwater in this type of terrain is localized and complex. In the White Hills, groundwater occurs not only in fractured or weathered bedrock, but also in pockets of alluvium that are quite deep and extensive relative to most occurrences of alluvium in the mountains. We conclude that the geology and the groundwater flow system in this area is very complex, possibly with many bedrock faults which create bedrock outcrops separated by small, alluvial, groundwater-bearing basins.

Five dry holes in the study area were drilled recently by

the BLM. All five wells were drilled mostly in crystalline bedrock in or near the mountains, whereas the major groundwater-bearing unit in the study area is the alluvium beneath the valleys. The wells are dry because they are unfavorably located with respect to a complex groundwater system in fractured or weathered bedrock. We have no specific evidence that drilling methods were responsible for any of the well failures.

Groundwater quality in the Detrital and Hualapai basins is moderate to good. Some constituents, principally heavy metals, are locally concentrated in areas affected by mining. The major cations and anions exhibit variations in concentration over roughly one order of magnitude, with values generally grouped near the ends of the range. The higher concentrations occur in wells near the perimeter of the alluvium, close to the surrounding mountains. In contrast, the sites exhibiting lower ionic concentrations generally occur in the central parts of the alluvial valleys. Possible reasons for this notable difference in water quality with location include (1) distance the water travels through weathered bedrock between the recharge area and the discharge point at the well, (2) density stratification within the groundwater, which keeps the more mineralized water below the level of most wells in the central alluvim, (3) availability of fresh recharge waters to the upper alluvium, and (4) immobilization of dissolved minerals by clay lenses within the alluvium.

Table 1, which is placed at the end of this chapter, comprises a summary of the wells we recommend for future water level monitoring. Six wells in Hualapai Valley, listed at the top of Table 1, are already being monitored annually by the U.S. Geological Survey. Monitoring of these six wells need not be duplicated by the BLM. Other information listed in Table 1 includes the length of previous record available for each selected well, a brief description of the local hydrogeologic

area the well is intended to represent, and in some cases, an alternative site.

Table 1: RECOMMENDED WELLS FOR FUTURE WATER-LEVEL MONITORING

	Well Number	Years of Available Data	Remarks
HUALAPAI VALLEY:	(22-16) 3cbb	1980-1982	Main basin, southern area
Hualapai Valley wells monitored annually by U.S. Geological Survey (USGS)	(23-13)32aca	1944-1982	Hackberry Wash
	(24-14)28cad	1943-1982	Lower Truxton Wash
	(24-16) 1ddd	1965-1982	Main basin, middle area
	(26-18) 3aaa1	1980-1982	Tributary valley south of Table Mountain Plateau
	(28-17) 31ccc	1965-1982	Main basin, north of Red Lake
HUALAPAI VALLEY: Main Basin	(22-16)26bac	1967, 1980	Main basin, southern area; alternate site is (22-15) 33dad, data available 1965, 1980.
	(23-15) 8cda	1965, 1980	Main basin, southern area; Optional
	(26-17)35aaa	1958-1980	Main basin, south of Red Lake; alternate site is (26-17)23ccc, data available 1958, 1980.
	(27-16)33baa	1965-1980	Main basin, northern Red Lake; alternate site is (27-17) 23cac1, data available 1973, 1980.

	Well Number	Years of Available Data	Remarks
HUALAPAI VALLEY:	(22-13) 9abc	1952, 1980	Hackberry Wash
Truxton Wash-Hackberry Area	(23-13)19dcb	1944-1981	Upper Truxton Wash; well shows water level decline 1944-1965, then rise 1965-1981.
	(23-13)29aaa1	1943, 1944, 1980	At mouth of Truxton Canyon
	(23-14)24bab1	1965, 1980	Upper Truxton Wash; well shows water level decline 1965-1980, versus wells (23-13)19dcb, (23-14)3adc, (24-14)29aaa
	(23-14) 3adc	1943-1980	Lower Truxton Wash; well shows water level decline 1943-1965, then rise 1965-1980.
	(24-14)29aaa	1944, 1952, 1964, 1980	Lower Truxton Wash; well shows same trend (water level decline 1944-1964, rise 1964-1980) as USGS well (24-14) 28cad, but with less extreme fluctuations.
YOUNGER VOLCANICS NEAR KINGMAN	(21-17)3cda4	1979, 1982	Up-gradient data point north of flow barrier.
	(21-17)14ccb	1978	Down-gradient data point north of flow barrier; alternate site is (21-17)14bcc, data available 1978.
	(21-17)23bbb	1977	South of flow barrier; alternate site is (21-17) 24bca, data available 1979.

	Well Number	Years of Available Data	Remarks
DETRITAL VALLEY	(25-19)11cbd	1978	Near Dolan Springs; alternate site is (25-19)3ccc, data available 1981 only.
	(25-19)30aaa	1966, 1979	Well cluster SW of Dolan Springs; only well in Detrital Valley alluvium with more than one year of water level data.
	(25-20)15aaa	only one measurement; date unknown	Well farthest down-gradient in well cluster SW of Dolan Springs.
	(26-19)36ccb	1978	Stream channel NE of Dolan Springs; alternate site is (25-19)1bab, data available 1981.
	(27-21)24cdd	1976	Mid-valley well cluster; alternate sites are: (27-21) 24bdc, data 1978; 25baa, data 1980; 25ddc, data 1965.
	(28-21)20aac	1980	Alluvial fan west side of north Detrital Valley.
	(28-21)26bbd	1981	North Detrital Valley
	(29-21)35ccc	1977	North Detrital Valley

	Well Number	Years of Available Data	Remarks
NORTHERN SACRAMENTO VALLEY:	(22-18)3aad	1982	Upthrown side of main "fault"; alternate site is (23-18) 35ccc, data 1973.
Wells on cross-section CC' (Figure 6)	(22-18)5dbc	1969	Downthrown side of main "fault"; down-gradient data point for three wells with deep piezometric surface.
	(23-18)32dad1	1968	Downthrown side of main "fault"; up-gradient data point for three wells with deep piezometric surface.
	(23-18)33cbc	1981	Downthrown side of main "fault"; well with upper potentiometric surface versus three deep wells.
NORTHERN SACRAMENTO VALLEY:	(23-18)6aad	1982	Upthrown side of secondary "fault"
Wells on cross-section AA' (Figure 6)	(23-18)6adb	1969	Downthrown side of secondary "fault"; upthrown side of main "fault".
	(23-19)12acd	1982	Downthrown side of main "fault"; dry in 1982; water table may be near base of hole, so if water table rises, water level may become measurable.

Chapter II

INTRODUCTION

OBJECTIVES AND SCOPE OF STUDY

The general objective of this investigation is to characterize the groundwater flow system and make a limited water quality analysis for two desert basins in northwestern Arizona, the Detrital and Hualapai basins. The results of the study are intended to provide the U.S. Bureau of Land Management (BLM) with data for water resources planning and development in the area. The specific objectives of the investigation comprise the following: To determine the mechanism and direction of groundwater flow and the hydraulic gradient of the system; to relate this information to several recently-drilled BLM wells which are dry; and to determine why the dry holes occurred, including the extent to which drilling methods and geologic structure influenced the failure rate.

In general, the scope of the project involves collecting, tabulating and interpreting all available hydrogeologic data for the study area. Because recent groundwater studies (Gillespie and Bentley, 1971; Remick, 1981) have been done in the Hualapai basin but not in the Detrital basin, emphasis was placed primarily on collecting and analyzing new data for the Detrital Basin. Secondary emphasis was placed on updating and analyzing available data for the Hualapai basin. Specific project tasks are summarized as follows:

(1) Collect all available geologic and hydrologic data including literature, maps, driller's reports, well logs, well data tables, and data on aquifer hydraulic characteristics;

(2) Carry out a field examination of selected well and spring sites; confirm the existence and location of the sites; measure water level and discharge rates at wells; measure elevations and discharge rates of springs; take samples for

water quality analysis at selected sites; fill out field inventory forms provided by the BLM for each site field-checked;

(3) Compile all data collected by Geo/Resource Consultants (GRC)in the field, together with data from all other sources, into tables of well and spring data and tables of water quality data;

(4) Synthesize a geologic map from published literature and maps, and from geologic mapping by GRC based on aerial photograph interpretations;

(5) Compile a hydrogeologic map which includes geologic units, well and spring data, water level contour lines and groundwater flow lines based on GRC's interpretation of the data;

(6) Interpret and analyze the available data in order to describe the occcurrence, movement, availability and chemical quality of groundwater in the Detrital and Hualapai Valleys and the surrounding mountains;

(7) Select representative wells to be measured periodically by the BLM to detect and record changes of water level.

ATTACHMENTS INCLUDED WITH THE REPORT

The attachments listed below are included with this hydrogeologic report.

(1) Tables of well and spring data:

These tables, along with an explanation, appear in Appendix A. The well data table includes all wells in the study area for which we have any data. All wells in the table are located on Plate 1, the geologic map. The spring data table includes only the springs field-checked by GRC. All of these springs are located on both Plates 1 and 3, the geologic map and hydrogeologic map, respectively.

(2) Tables of water quality data:

These tables appear as Appendix B. The tables include data

for all sites sampled by GRC during the field investigation, as well as data from two other sources (Remick, 1981; Gillespie, Bentley and Kam, 1966).

(3) Completed well and spring inventory field forms for all sites field-checked by GRC.

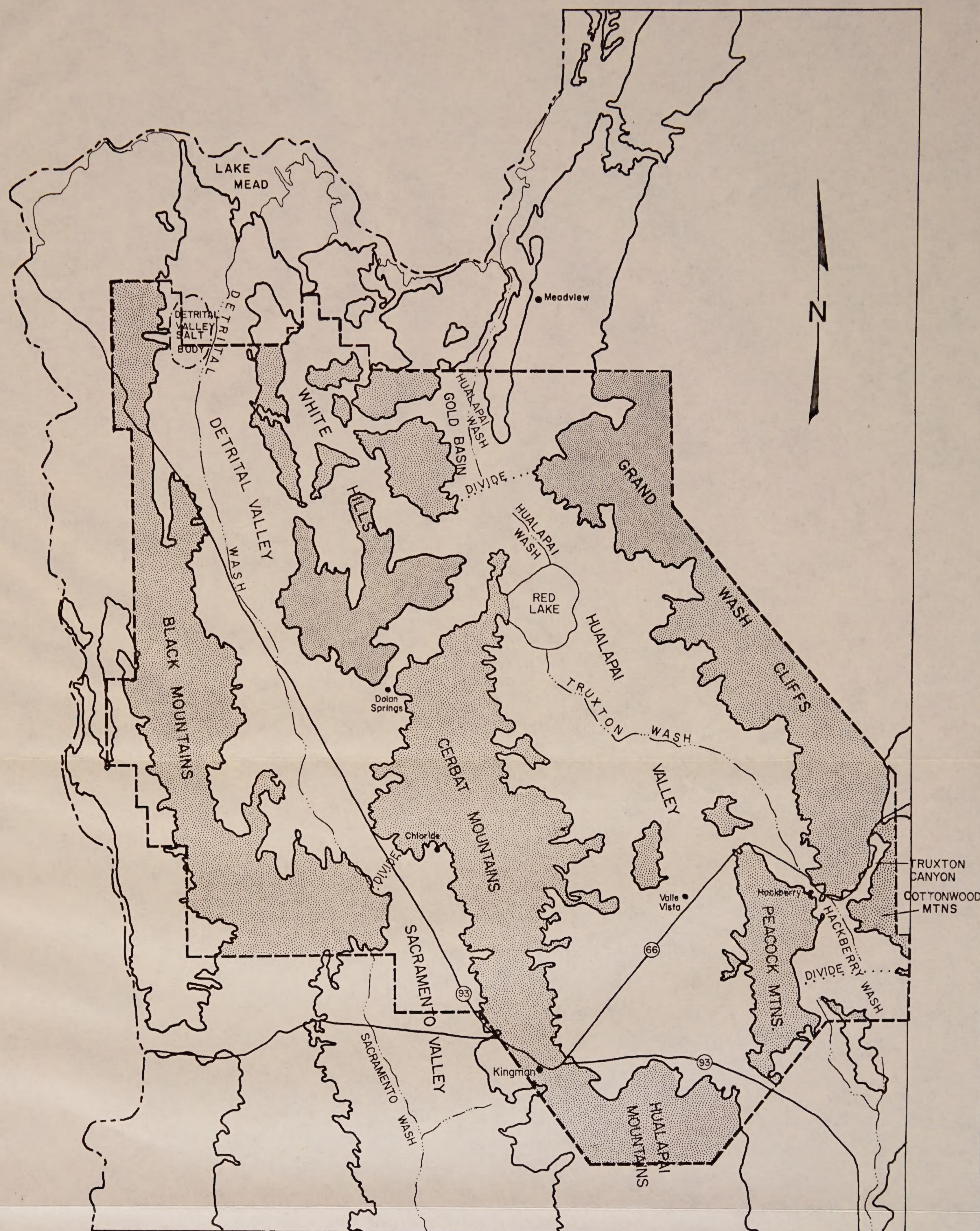
(4) Plate 1--Geologic Map of the Kingman Study Area: In addition to geology, the map includes symbols locating all of the wells and springs listed in the well and spring data tables (Appendix A), plus all of the springs within the study area mapped by Remick (1981), and any additional springs with post-1975 elevation measurements reported by the U.S. Geological Survey.

(5) Plate 2--Schematic East-West Geologic Cross-Section through the Kingman Study Area.

(6) Plate 3--Hydrogeologic Map of the Kingman Study Area: The specific data incorporated into this map are discussed in the introductory section of Chapter 5, Groundwater Occurrence and Movement.

STUDY AREA LOCATION

As shown on Figure 1, the study area extends over approximately 2,300 square miles in northwestern Mohave County, Arizona. The principal features in the area consist of the approximately north-south trending Detrital and Hualapai Valleys and their bounding mountain ranges, the Black Mountains, Cerbat Mountains, White Hills and Grand Wash Cliffs. The northern end of Sacramento Valley, which lies along strike with and south of Detrital Valley, also lies within the study area.



MOUNTAINS (in study area)

10 0 10 20
MILES

KINGMAN STUDY AREA LOCATION MAP

Reference: SEE TEXT		
Scale: AS NOTED	Approved by: TSD	Drawn by: dc
Geo / Resource Consultants, Inc. CONSULTING GEOLOGISTS / ENGINEERS / GEOPHYSICISTS 1620 MONTGOMERY STREET SAN FRANCISCO, CALIFORNIA 94111		
Job no. 263-IH	Date: 08/20/82	FIGURE I

FIELD INVESTIGATION

Extent of Coverage

In order to collect data for the hydrologic analysis and to verify the current status of many of the wells and springs in the study area, 134 sites were visited in the field during March, April and May 1982. The sites consisted of 120 wells and 14 springs. Most of the locations were known from data supplied by the U.S. Geological Survey and the Arizona Department of Water Resources; some were discovered in the field. Detrital Valley (including portions of the Black Mountains, Cerbat Mountains, and White Hills) and the Grand Wash Cliffs were covered extensively. Sixty seven sites were visited in Detrital Valley, and twenty in the Grand Wash Cliffs. This constitutes virtually every known well in Detrital Valley and many in the Grand Wash Cliffs. Because data from recent studies (Gillespie and Bentley, 1971; Remick, 1981) are available for Hualapai Valley, less field time was spent there than in Detrital Valley. Our approach in Hualapai Valley was to verify existing conditions and document changes which occurred since Remick completed his investigation in 1980. Also, less field time was spent in Sacramento Valley. Approximately 25 percent of the wells and springs in Hualapai Valley and 50 percent of those in the northern portion of Sacramento Valley were field-checked.

Data Collected

A variety of data was collected at each site and recorded on standard well and spring schedule forms provided by the BLM. Additional data, which may be useful to future investigators, are included in the "remarks" section of the schedule forms. Sketch maps of each site are provided, and driller's logs and water chemistry analyses are included for sites where this information was available in the field. Whenever water depth, discharge, or other measurements were made by the land owner or a party other than the field investigator, the source of the

measurement is clearly noted on the form. In some instances, landowners provided very useful information which otherwise would have been impossible to obtain.

The Area Manager of the Bureau of Land Management, Kingman Resource Area, sent a letter to many of the local landowners. In the letter he requested permission for access to private property for GRC personnel so that the field work could be carried out. A form was included on which the property owner could grant or deny permission for access to the site, and the form was to be returned to the BLM. Approximately 50 percent of those persons contacted returned the forms. Most of the landowners were also approached in person by the field investigator. All except one family granted permission for site access. That family provided a certain amount of information about their wells, but would not allow the sites to be visited. Because this family owns a large portion of the land in the southern Hualapai Valley, the field investigator could not measure water depths or collect samples at many sites in that area.

Maps used in the course of the field work were seven-and-one-half-minute topographic quadrangles published by the U.S. Geological Survey (USGS) during the period from 1959 to 1968. Some were revised in 1980 using recent aerial photographs. The only widely available maps that cover the northwestern portion of the study area are fifteen-minute topographic quadrangles published by the USGS in 1953, 1959 and 1960. Seven-and-one half-minute maps of this area are available as blueline reproductions from USGS headquarters. Certain roads and other cultural data depicted on the maps are located inaccurately. In these cases, the sketch maps on the BLM schedule forms should be referred to by future field investigators.

A four-wheel-drive vehicle was used to conduct the field work. Only in a few cases was the four-wheel-drive function utilized, but the high clearance of the vehicle was needed to

reach several of the sites.

<u>Equipment</u>

Ground surface elevation was determined with an American Paulin System Terra Surveying Altimeter, Model T-5. The range of the instrument is from -600 feet to 10,000 feet, with gradations every five feet. Benchmarks located in the field were used to calibrate the altimeter at known elevations, and temperature corrections were applied to all readings. Large fluctuations in barometric pressure, caused by unstable weather conditions, interferred with the accuracy of the instrument on some days. Elevation data supplied by the USGS were used for sites visited on those days. The source of the elevation data used is shown on the well and spring schedule forms.

At well sites where water samples could not be obtained by pumping, bailed samples were taken using bottom-filling polyvinyl chloride cylindrical samplers, which have a slot-cut screen at the intake and a check valve. A one-sixteenth-inch diameter steel cable was used to lower and retrieve the samplers.

Water samples were collected and stored in 250 milliliter polyethylene bottles. Every ten days, samples were shipped for analysis to the USGS Water Resources Division Central Laboratory in Arvada, Colorado.

Where flow meters were absent, well and spring discharge rates were measured volumetrically. That is, the time taken to fill a container of known volume was measured.

Depths to water were measured with an Actat Corporation Olympic Well Probe, Model 1000. This battery operated device measures differences in electrical resistance to detect the water level, and it uses the standard needle-type indicator. The range of the instrument is from zero to 1000 feet, with gradations every five feet.

Acidity/alkalinity of water samples was measured with a

Barnant Corporation Digital pH Meter, Model #501-3134. The range of the instrument is from zero to 14 with gradations each 0.01 unit. It is portable and battery powered. Before each reading, the instrument was calibrated using standard solutions of pH four, seven and ten, supplied by the USGS Water Resources Division. Excellent agreement was achieved between field-determined pH values and those measured by the testing laboratory.

Specific conductivity of the water samples was measured with a battery powered Hach Chemical Company Portable Conductivity Meter, Model 16300. The meter functions over the ranges of zero to two, zero to 20, zero to 200, zero to 2000, and zero to 20,000 micromhos per centimeter (cm). The gradations are from 0.01 micromhos/cm for the zero to two range, to 100 micromhos/cm for the zero to 20,000 range. Most conductivity values measured in the field agreed very well with those reported by the testing laboratory.

Some of the determinations made in the laboratory require filtered water samples. This type of sample was prepared by using a 250 milliliter capacity Millipore Corporaton Sterifil 47 millimeter (mm) Aseptic Filtering System, Catalog Number XX11 047 00, in conjunction with a four-inch stroke, stainless steel Manual Vacuum/Pressure Pump, Catalog Number XX62 000 35. White, ungridded filters, 47mm in diameter with pores 0.45 microns in size, were used in the filtering system. Samples prepared with this system contain dissolved solids only, without any suspended material.

Chapter III

PHYSIOGRAPHY AND SURFACE DRAINAGE

This chapter begins with a discussion of the valleys and bounding mountain ranges in the study area and the surface drainage patterns. Also included in the chapter are brief descriptions of the climate, streamflow and infiltration, and settlement and water use. Geographic features discussed in this chapter are shown on Figure 1.

VALLEYS, BOUNDING RANGES AND SURFACE DRAINAGE

Detrital Valley is bounded on the west by the Black Mountains, on the east by the White Hills and Cerbat Mountains, and on the south by a low topographic rise (elevation nearly 3500 feet) which forms the drainage divide between Detrital and Sacramento Valleys. Surface drainage in Detrital Valley flows from the mountains toward the valley center and then north, via Detrital Wash, to the Colorado River at Lake Mead. The valley floor slopes northward from nearly 3,500 feet at the southern drainage divide to less than 1,600 feet in northern Detrital Wash. Mountain peaks to the east and west range from 5,000 to 7,000 feet in elevation.

Sacramento Valley is bounded on the west by the Black Mountains, on the east by the Cerbat Mountains and Hualapai Mountains, and on the north by the drainage divide with Detrital Valley. Drainage in Sacramento Valley flows from the mountains toward Sacramento Wash in the valley center, then south, and finally west, eventually draining into the Colorado River.

In contrast to Detrital and Sacramento Valleys, Hualapai Valley is a basin of closed surface drainage. The valley extends from the Cerbat Mountains and White Hills on the west to Grand Wash Cliffs on the east, and from the Hualapai and

Peacock Mountains on the south to a low topographic divide (elevaton 2864 feet) about five miles north of Red Lake. Another low topographic divide (elevation approximately 3900 feet) occurs at the southeast end of Hualapai Valley near the town of Hackberry, between the Peacock Mountains and the Cottonwood Mountains. Although groundwater exits the basin at these two topographic divides, surface water drains into the basin from all sides. The Red Lake playa marks the lowest point of surface drainage in Hualapai Valley.

There are three main dry washes in Hualapai Valley. Truxton Wash, the principal stream in Hualapai Valley, enters the project area at the head of Truxton Canyon. Hackberry Wash, which begins near the low topographic divide southeast of Hackberry, drains northward to meet Truxton Wash at the mouth of the Truxton Canyon. From this junction, Truxton Wash slopes gently northward to Red Lake. It is fed by intermittent streams draining from the mountains to the south, east and west. Hualapai Wash is divided into northward and southward flowing portions by the low topographic rise which defines the northern end of Hualapai Valley. The smaller, southern portion of Hualapai Wash slopes from the drainage divide southward to Red Lake. The main and northern portion of Hualapai Wash drains northward from the divide into the Gold Basin and eventually to Lake Mead.

The floor of Hualapai Valley slopes northward from about 4,000 feet at the southern end to 2,750 feet at Red Lake. Mountain peaks to the east and west range from 6,000 to 7,000 feet in elevation, and in the Hualapai Mountains to the south, elevations exceed 8,000 feet.

CLIMATE

The climate in the study area is typically semi-arid; precipitation and humidity are low, and summer temperatures and evaporation rates are high. In general, the annual precip-

itation increases with altitude. Average annual precipitation ranges from six or eight inches at Red lake and in the northern Detrital Valley, to twelve inches or more in the mountains. Most of the precipitation occurs in the typical summer storm pattern, which involves warm, moist air flowing in from the Gulf of Mexico or the Gulf of California. The upward movement of this air over the hot deserts and mountain barriers produces high-intensity summer thunderstorms. A secondary peak in precipitation, which occurs during the winter months, is associated with long-duration storms moving inland from the Pacific Ocean. Normal winter temperatures are in the fifties and sixties (degrees Fahrenheit) in the afternoons and near freezing at night. Summer temperatures are usually in the upper nineties in the afternoons. Estimated average annual pan evaporation at Red Lake is 130 to 135 inches. The estimated average annual lake evaporation at Red Lake is 80 inches. Sources for the climatological data discussed above include Gillespie and Bentley (1971), Sellers and Hill (1974), and Arizona State University (1975).

STREAMFLOW AND INFILTRATION

Gillespie and Bentley (1971, p. 7-9, 17-18, 22) discuss stream flow and infiltration in Hualapai and Sacramento Valleys. Because of the proximity of and similarities between Detrital, Hualapai and Sacramento Valleys, we assume that the discussion of streamflow and infiltration below, taken from Gillespie and Bentley, applies to all three valleys.

Essentialy all of the streams in the study area are ephemeral. Substantial stream flow in the mountains occurs in direct response to the long-duration winter storms and the high-intensity summer thunderstorms. However, the surface flow rarely reaches the central parts of the valleys because most of it is lost to infiltration and evapotranspiration. Most of the infiltration takes place in the coarse alluvium on the upper

and middle portions of the alluvial fans, which slope from the base of the mountains to the valley floors. Some of the infiltrated runoff eventually recharges the phreatic zone of groundwater. Surface runoff is more likely to reach the valley centers when associated with longer duration storms. Most of the rare runoff that reaches Red Lake is lost to evaporation because the relatively impermeable playa deposits do not allow significant infiltration.

SETTLEMENT AND WATER USE

The only major community in the study area is Kingman, which lies in the low saddle between the Cerbat and the Hualapai Mountains. Smaller towns in the study area include Dolan Springs in Detrital Valley, Chloride in Sacramento Valley, Hackberry in southeastern Hualapai Valley, and Valle Vista in south-central Hualapai Valley. Groundwater is the main source of water in the study area, and the largest volumes of groundwater consumption are concentrated near these five communities. The two greatest water requirements are for municipal water supplies at Kingman, Dolan Springs, Chloride and Valle Vista and for irrigation near Kingman, Hackberry and Valle Vista. Additional groundwater pumpage for domestic use, stockwatering and small industry is scattered throughout the study area.

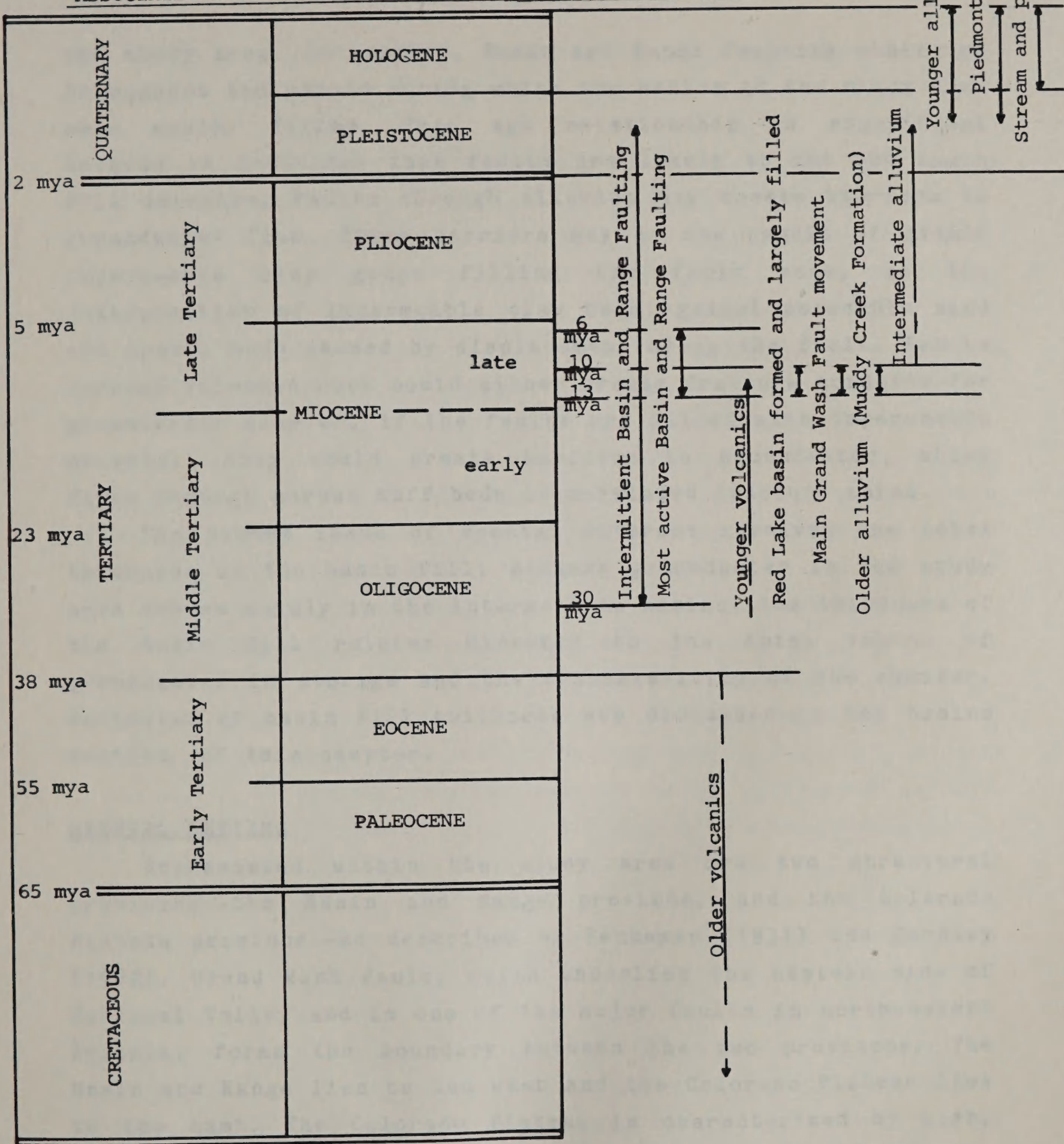
Chapter IV

GEOLOGY

This chapter contains a general discussion of the geologic structure and stratigraphy in the study area. These aspects of the geology are critical to understanding the groundwater system, because they relate directly to the distribution, volume and flow rates of groundwater. The chapter begins with a description of the overall structural setting of the study area and a brief description of the Basin and Range disturbance, which was the geologic event responsible for the predominant structural features. Next, more detailed structure and stratigraphy in the mountain ranges and in the basins are discussed. The Detrital Valley and Red Lake salt bodies, which occur in the Detrital and Hualapai basins, respectively, are covered in a separate section of the chapter. The significance of the salt bodies is discussed at the beginning of that same section. Finally, the characteristics, distribution and water-bearing properties of each of the stratigraphic units in the study area are described in the last section of the chapter. Plates 1 and 2, the geologic map and the schematic geologic cross-section, depict the various geologic units and structures described in this chapter.

Throughout the discussion below, special attention has been paid to two critical issues. The first issue is the age of Basin and Range faulting relative to the age of the volcanic and alluvial basin fill. Our interpretation of this age relationship, based on compilation of data in the literature (Pierce, 1976 and 1981; Gillespie and Bentley, 1971), is summarized graphically in Figure 2. Figure 2 shows the Cenozoic geologic time scale, as well as time intervals associated with Cenozoic geologic events and stratigraphic units pertinent to

CENOZOIC GEOLOGIC TIME SCALE AND TIME INTERVALS
ASSOCIATED WITH GEOLOGIC EVENTS AND STRATIGRAPHIC UNITS



NOTE: Cenozoic ages based on Labreque, Kent and Cande (1977); Time intervals associated with geologic events and stratigraphic units compiled by GRC on the basis of work by Pierce (1976; 1981) and Gillespie and Bentley (1971).

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CENOZOIC GEOLOGIC TIME SCALE

FIGURE 2

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the study area. In summary, Basin and Range faulting continued throughout the period during which the basins in the study area were mostly filled. This age relationship is significant because it indicates that faults are likely to cut the basin fill deposits. Faults through alluvium may create barriers to groundwater flow. These barriers may be the result of either impermeable clay gouge filling the fault zone, or the juxtaposition of impermeable clay beds against permeable sand and gravel beds caused by displacement along the fault. Faults through volcanic rock could either create fracture conduits for groundwater flow or, if the faults are filled with impermeable material, they could create barriers to groundwater, which flows through porous tuff beds or unrelated fracture zones.

The second issue of special interest involves the total thickness of the basin fill. Because groundwater in the study area occurs mainly in the intermontane basins, the thickness of the basin fill relates directly to the total volume of groundwater in storage and the transmissivity of the aquifer. Estimates of basin fill thickness are discussed in the basins section of this chapter.

GENERAL SETTING

Represented within the study area are two structural provinces--the Basin and Range province, and the Colorado Plateau province--as described by Fenneman (1931) and Eardley (1962). Grand Wash Fault, which underlies the eastern side of Hualapai Valley and is one of the major faults in northwestern Arizona, forms the boundary between the two provinces. The Basin and Range lies to the west and the Colorado Plateau lies to the east. The Colorado Plateau is characterized by high, dissected plateaus underlain by flat-lying or gently dipping Paleozoic and Mesozoic sedimentary rocks, which are broken into large blocks by faults. The Basin and Range province is characterized by tilted fault-block mountain ranges separated

by sediment-filled basins. The mountain ranges and basins typically strike north-south, and the dominant style of faulting is normal.

The characteristic structure of the Basin and Range province was developed during the Basin and Range disturbance, which began approximately 30 million years ago and continued to fairly recent times (Hayes, 1969, p. 50). Four major processes associated with the disturbance define the structure and stratigraphy found in the region today. Those processes consist of uplift of mountain ranges by block faulting, volcanic activity, filling of basins with volcanic flows and sediments eroded from the mountains, and evaporite deposition during periods when the intermontane basins were closed off from drainage to the sea. With regard to geologic processes during the Basin and Range disturbance, Morrison (in Hayes, 1969, p. 43) states the following:

> "During middle and late Cenozoic time orogeny in the Basin and Range province created down-faulted basins and up-faulted mountain ranges. The faulting took place intermittently from early middle through late Cenozoic time, but was most active between 30 million and 6 million years ago. Terrestrial sediments, commonly several thousands of feet thick, were laid down in the intermontane basins. An episode of intense volcanism 30 million to 20 million years ago produced widespread dacitic, andesitic, and rhyolitic flows and tuffs, commonly several thousand feet thick, that now cap many of the mountan ranges in the Basin and Range provice. Another episode of intermittent volcanism, when mainly basalt and andesite were erupted, took place during the late Cenozoic at centers both in the Basin and Range province and in the Colorado Plateau province.
>
> "The faulting and volcanism repeatedly disrupted drainage patterns in the Basin and Range province and

caused many of the intermontane basins to be closed off from drainage to the sea."

Hayes (1969, p. 50) states that most of the range-front faults developed during the Basin and Range disturbance have since been buried in alluvial debris derived from the ranges.

More recent work has further refined the time period of most active Basin and Range faulting. Eberly and Stanley (1978) and Scarborough and Pierce (1978) indicate that Basin and Range faulting occurred subsequent to 13 million years ago, during late Miocene time.

MOUNTAIN RANGES IN THE STUDY AREA

Within the study area, the Black, Cerbat, Hualapai and Peacock Mountains are all tilted fault blocks characteristic of the Basin and Range province. North-striking normal faults apparently flank the western sides of the ranges, with downthrown sides to the west (Gillespie and Bentley, 1971, p. 7-9; Arizona Bureau of Mines, 1962). The faults are concealed by thick alluvium and are therefore difficult to locate precisely. The mountains consist of Precambrian igneous and metamorphic rocks overlain unconformably by Cretaceous to Tertiary older volcanic rocks and middle to late Tertiary younger volcanic rocks (Gillespie and Bentley, 1971). We infer that the younger volcanic rocks probably correlate with both of the volcanic episodes described by Morrison above. Remnants of the pre-basin volcanic strata (older volcanics and some younger volcanics) dip as much as 20 degrees east in both the Cerbat and Black Mountains, suggesting eastward tilting of each of these fault blocks (Pierce, 1976, p. 328; Gillespie and Bentley, 1971, p. 9).

In contrast to the other mountain ranges in the study area, the Grand Wash Cliffs form the western edge of the Colorado Plateau provice. Grand Wash Fault, the subsurface

counterpart of Grand Wash Cliffs, is a normal fault with the downthrown side to the west. Pierce (1976, p. 328) believes that the maximum differential vertical displacement along this fault in the vicinity of the Hualapai basin is approximately 16,000 feet. He further concludes that most of the differential movement occurred between 13 and 10 million years ago and that the fault movement is a manifestation of the Basin and Range disturbance (Pierce, 1976, p. 332-333; Pierce, 1981, p. 3). According to Gillespie and Bentley (1971, p. 9), about 1,000 feet of displacement has occurred along the fault since the emplacement of the younger volcanic rocks (middle to late Tertiary) in the Grand Wash Cliffs and Peacock Mountains.

The Grand Wash Cliffs consist of Precambrian igneous and metamorphic rocks capped by Paleozoic sedimentary rocks (Cambrian and Devonian) that dip gently east. The younger volcanic rocks (middle to late Tertiary) found elsewhere in the study area also outcrop along the cliffs.

BASINS IN THE STUDY AREA

The Hualapai, Detrital and northern Sacramento Valleys are the surface expressions of the basins formed between the Black Mountain, Cerbat Mountain and Grand Wash Cliffs tilted fault blocks. As the fault blocks lifted and rotated, the basins filled with younger volcanic flows associated with the Basin and Range disturbance, clastic sediments eroding off the mountains, and, during periods of internal drainage, evaporite deposits. Two of the major bedded salt deposits in Arizona underlie the northern Detrital Valley and the central Hualapai Valley. The latter is known as the Red Lake salt deposit. Estimates for total thickness of the basin fill are still speculative. Gillespie and Bentley (1971, p. 6) report that basin fill in the Hualapai and Sacramento basins is greater than 4,000 feet thick. More recent geophysical data indicate that fill beneath Hualapai Valley extends to a depth of more

than 10,000 feet (Pierce, 1976, p. 330; Pierce, 1981, p. 3; Van der Harst, 1982). Data regarding basin fill thickness beneath Detrital Valley are sparse. In the northern Detrital Valley, the combined alluvium and bedded salt deposits are at least 1,000 feet thick (Pierce, 1981, p. 3; Hayes and Lukes, 1974, p. 34-35).

Gillespie and Bentley (1971) have divided the alluvial deposits within the basin into older, intermediate, and younger alluvium. The older alluvium is late Tertiary in age. It includes the bedded salt deposits, and is underlain by and interbedded with the younger volcanics (middle to late Tertiary). The intermediate alluvium is late Tertiary and Quaternary. The younger alluvium is Quaternary, and it can be further differentiated into piedmont deposits (Pleistocene to Holocene), stream deposits (Holocene), and playa deposits (Holocene).

Through his work on Basin and Range evaporite deposits, including the Detrital Valley and Red Lake salt deposits, Pierce (1976; 1981) has helped to refine the age brackets of the Detrital and Hualapai basin fill. Pierce correlates the salt deposits in both basins with the late Tertiary Muddy Creek Formation of the larger Lake Mead region. Furthermore, in 1976 he concluded that the Red Lake (Hualapai) basin was formed, by differential movement between the Cerbat and Grand Wash Cliffs fault blocks, and largely filled between 16 and 10 million years ago, during late Miocene time. In 1981, Pierce refined this time bracket to between 13 and 10 million years ago, based on new evidence that the Basin and Range disturbance took place subsequent to 13 million years ago (Stanley and Eberly, 1978; Scarborough and Pierce, 1978). We point out that the older alluvium of Gillespie and Bentley, a major portion of which is the Red Lake salt deposit, represents 95 per cent or more of the total thickness of basin fill in the Hualapai basin. Therefore, as Pierce concludes that the Red Lake basin was

formed and "largely filled" between 13 and 10 million years ago, we infer that his time bracket pertains to the age of the older alluvium. Furthermore, because of the similarities between and proximity of the Detrital, Sacramento and Hualapai basins, we infer that the age of basin fill in the former two basins probably correlates with that defined by Pierce for the Hualapai basin.

RED LAKE AND DETRITAL VALLEY SALT BODIES

The hydrogeologic significance of salt bodies within the alluvial groundwater basins is three-fold. First, because salt is relatively impermeable, a large salt body in a groundwater basin will probably impede groundwater flow substantially. Second, the presence of large volumes of salt beneath the water table is likely to have a deleterious effect on groundwater quality. Third, the salt bodies are of interest because they are potential targets for exploitation. The U.S. Bureau of Land Management has studied the feasibility of mining salt from the Detrital Valley salt body (U.S. Dept. of the Interior, Bureau of Land Management, 1974). Southwest Gas Company is planning to construct a natural gas storage facility in the Red Lake salt body (Pierce, 1981b). The interest already expressed in developing these evaporite deposits has generated drill hole data, seismic data and pump test data, all of which have enhanced the data base pertinent to understanding the groundwater system. Furthermore, if either of these salt bodies are exploited in the future, the development would probably include industrial use of groundwater pumped from the alluvial basin.

Red Lake Salt Body

Three deep exploration holes just south of Red Lake provide the only direct data available on the Red Lake salt deposit. Two of these holes (Kerr McGee R.L. 1 or (26-16)

30ddd; and Kerr McGee R.L. 2 or (26-16) 28ddc) were drilled by Kerr McGee in 1958. The third and deepest hole (El Paso R.L.1 or (26-16) 22cc) was drilled by El Paso Natural Gas Company in 1970. Well logs for these holes have been published by the Arizona Bureau of Mines (1975). These well logs indicate that at least 1,500 to 1,800 feet of other sedimentary materials overlie the evaporite deposits. This overlying material is dominated by thick clay beds, which increase in thickness to the east. Permeable beds of sand and gravel, 20 to 60 feet thick, are interbedded with the clay. The deepest of the three holes was approximately 6,000 feet deep and it failed to encounter the base of the evaporites. Thus, the Red Lake salt body is known to be at least 4,000 feet thick. The salt body apparently consists mostly of thick halite, although gypsum and anhydrite were also encountered at the top of the evaporite sequence.

The gross dimensions of the Red Lake salt body have been inferred from geophysical studies by the U.S. Geological Survey and El Paso Natural Gas Company (Randolph, 1971). The salt body may be on the order of twelve miles long parallel to the length of Hualapai Valley, five miles wide and two miles thick. Consistent with this data, Pierce (1981) estimates that the salt body could be as thick as 10,000 feet.

On the basis of seismic surveys by CER Corporation, Van der Harst (1982) indicates that the Red Lake salt is a large wedge-shaped body that abuts against Grand Wash Fault and extends westward to a fault on the east side of the Cerbat Mountains. The salt thickness increases from zero feet on the west to 9,000 feet on the east, with the thickest portion near Grand Wash Fault.

Another significant feature inferred from the geophysical studies discussed above is that of a buried bedrock shelf at the northern end of the Red Lake basin (Pierce, 1976; 1981). This bedrock shelf apparently closed off the drainage basin,

creating the conditions necessary for evaporite deposition. Red Lake Playa is a contemporary surface feature which indicates the continued existence of internal drainage in the Hualapai basin. Today's surface drainage divide north of Red Lake probably corresponds with the buried bedrock shelf.

Detrital Valley Salt Body

The Detrital Valley salt body extends over several square miles in townships 29 and 30 north, range 21 west. Information about the deposit is based on data from a dozen or more exploration holes. Well logs for these holes are filed with the Arizona Bureau of Geology and Mineral Technology.

Pierce (1981) summarizes present information about the Detrital Valley salt as follows. The salt body occurs from 300 to 800 feet beneath the surface and obtains a maximum thickness of 715 feet. The elevations of tops of the evaporites are similar to those in the Red Lake salt body. The elevations also correspond to outcrop elevations of gypsum belonging to the Muddy Creek Formation which are found on the south side of Lake Mead. Thus, Pierce concludes that both the Detrital Valley and Red Lake salt bodies belong to the Muddy Creek Formation.

STRATIGRAPHIC UNITS AND THEIR WATER-BEARING PROPERTIES

The following discussion of stratigraphic units and their water-bearing properties is based primarily upon the work by Gillespie and Bentley (1971). In summary, the older alluvium which underlies the valleys is the main aquifer in the study area. It both stores and yields the most water. Secondarily, the younger volcanics are the most important aquifer in the mountain areas. The unit yields moderate amounts of water to wells near Kingman. However, because the groundwater in these volcanic rocks occurs mostly in fractures, the groundwater storage is limited.

Igneous and Metamorphic Rocks

Igneous and metamorphic rocks, mostly Precambrian in age, constitute the oldest unit in the study area. The unit outcrops extensively in all of the mountain ranges. It forms the basement complex, and is generally the lowermost barrier to groundwater movement. The unit comprises Precambrian granite, gneiss and schist. Also included are small granitic intrusives of late Cretaceous to early Tertiary age, which are associated with copper-bearing rocks that have been mined near Chloride. The rocks generally do not yield water except along fractures and weathered zones. Wells tapping weathered zones up to 100 feet thick produce low yields, generally one to five gallons per minute, and up to as much as 30 gallons per minute. Many small springs also issue from these rocks.

Paleozoic Sedimentary Rocks

Paleozoic sedimentary rocks cap the Grand Wash Cliffs. The rocks consist of Devonian limestone underlain by the Cambrian Tonto Group. The latter includes in descending order the Mauv Limestone, Bright Angel Shale, and Tapeats Sandstone. These rocks do not yield significant amounts of water to wells within the study area. However, because the strata dip eastward, water infiltrating these beds moves down dip and emerges as springs in canyons on the Colorado Plateau (Twenter, 1972, p. 27-28). Huntoon (1977) describes the target aquifers in these sedimentary rocks on the Colorado Plateau.

Older Volcanic Rocks

The older volcanic rocks consist of andesite and latite flows and tuff beds, and include some interbedded detrital deposits. The unit includes the Cretaceous (?) Gold Road Latite of Wilson (1962, p. 53-54) in the Black Mountains and White Hills. The older volcanics form the main mass of the Black Mountains, outcrop extensively in the White Hills, and occur as

isolated exposures in the Cerbat Mountains. The unit is several hundred feet thick in the Black Mountains. Gillespie and Bentley date this unit as Cretaceous(?) to Tertiary. These rocks do transmit some water through fractured zones and tuff beds, but they do not yield significant volumes of water to wells.

Younger Volcanic Rocks

The younger volcanic rocks consist of middle to late Tertiary basalt flows, basaltic andesite flows and tuff, and rhyolite tuff and ignimbrite. These rocks underlie and are interbedded with the older alluvium. The main exposures are in the Kingman area, Black Mountains and White Hills. Additional small isolated exposures occur in all of the mountains in the study area, except for the Hualapai Mountains.

The younger volcanic rocks yield moderate amounts of water to wells near Kingman, where the total unit thickness is estimated to be approximately 1,400 to 1,800 feet. The water occurs in fractures and in interbedded agglomerate and gravel of the older alluvium. Two large fault zones providing continuous passages for the storage and movement of water in the Kingman area are discussed by Gillespie and Bentley (p. 11-12). They also discuss two distinct groundwater reservoirs, divided where these fault zones become barriers to, rather than conduits for, groundwater movement. Only the upper 230 feet of younger volcanics at Kingman have been penetrated by wells. Large yields could probably be obtained from wells drilled deeper into these rocks. However, because of the limited storage associated with groundwater in fractured rock, long term pumping in these potentially high-producing wells would probably drain the aquifer.

A sequence of younger volcanic rocks approximately 570 feet thick outcrops in the Grand Wash Cliffs. However, the volcanics here lie above the water table, and therefore do not

contain water.

On the eastern side of the southern Black Mountains where they border the Sacramento Valley, many springs issue from the base of eastward-dipping tuff beds. These tuff beds also yield small amounts of water to a few wells in the area.

Older Alluvium

The late Tertiary older alluvium is the lowermost sedimentary unit beneath the valleys, and it is exposed in isolated outcrops near the mountains, especially in the White Hills. The unit consists of moderately consolidated fragments of granite, schist, gneiss and volcanic rocks in a silty clay or sandy matrix. Poorly consolidated tuff and agglomerate beds associated with the younger volcanics are interbedded with the alluvium. Also included in the unit are the thick evaporite deposits, which underlie the central Hualapai and northern Detrital Valleys, and which Pierce (1976; 1981) correlates with the late Tertiary Muddy Creek Formation.

The grain size in the alluvium decreases from pebble and boulder size near the mountains to coarse sand and interbedded clay and silt in the valleys. The unit occurs as ancient dissected alluvial fans and valley-fill deposits of fluvial and lacustrine origin. Where the older alluvium is exposed, it stands in vertical cliffs 10 to 50 feet high; the rocks show some vertical fractures and normal faulting with displacements of less than one foot, and the strata dip as much as 10 to 15 degrees.

The older alluvium is the principal aquifer in the valleys. The unit has low to moderate permeabilities and it yields moderate to large amounts of water to wells.

Intermediate Alluvium

The intermediate alluvium is late Tertiary and Pleistocene in age. It occurs as an extensive near-surface deposit 200 to

300 feet thick beneath the valley floors, and it is exposed in isolated outcrops near the mountains. The unit consists of weakly to moderately consolidated fragments of granite, schist, gneiss and volcanic rocks. As with the older alluvium, the intermediate alluvium occurs as dissected alluvial fans and valley-fill deposits with grain size decreasing with distance from the mountains. Grain sizes for the latter unit range from pebble and boulder size near the mountains to fine gravel, sand and silt in the middle of the valleys.

The intermediate alluvium has low to high permeabilities, but is generally dry because it lies above the water table. Nevertheless, near the mountains where the unit overlies shallow bedrock, the alluvium is saturated and will yield moderate amounts of water, 10 to 50 gallons per minute, to wells.

<u>Younger Alluvium</u>

The younger alluvium is Quaternary in age, and it has been divided into piedmont deposits, playa deposits and stream deposits. The unit is generally above the water table, and therefore dry, except in some mountain canyons where stream deposits yield small amounts of water to wells.

The piedmont deposits are Pleistocene and Holocene in age. They consist of poorly consolidated silt, sand, gravel and boulders derived from granite, schist, gneiss and volcanic rocks. The deposits, which are up to 50 feet thick, overlie terraces, alluvial fans, piedmont slopes and valley floors. Although these sediments are highly permeable, they are generally drained of water.

The playa deposits are Holocene in age and they are exposed at Red Lake only. The deposits consist of unconsolidated silt and clay, which are relatively impermeable. The deposits do not yield water to wells.

The stream deposits are Holocene in age, and they consist

of unconsolidated sand and gravel derived from granite, schist, gneiss and volcanic rocks. The unit occurs in streambeds, where it is generally no more than a few feet thick. These sediments are highly permeable, but generally drained of water. However, in mountain canyons where the unit is underlain by shallow bedrock, the stream sediments yield small amounts of water to wells.

Chapter V

GROUNDWATER OCCURRENCE AND MOVEMENT

This chapter begins with an introductory section that includes three topics. The first is a description of Plate 3, the hydrogeologic map, including the data incorporated into the map and the nature of interpretations made from those data. Next, two general assumptions we made regarding groundwater flow in the alluvial valleys are discussed. These assumptions were necessary because of the sparsity of certain types of data and the regional scale of the study area. The third introductory topic involves the source and nature of recharge to groundwater in the study area. The following sections of this chapter contain detailed discussions of the occurrence and movement of groundwater in the various alluvial valleys and bedrock mountain areas. The chapter closes with our interpretation of why several recently-drilled BLM wells were dry.

GENERAL REMARKS

Plate 3, the hydrogeologic map, incorporates all of the hydrogeologic data collected and compiled by GRC, and it depicts our interpretation of the groundwater flow system based on these data. In order to emphasize the overall geologic framework, the geology shown on Plate 3 is simplified from that on Plate 1, the geologic map; the various types of alluvium have not been differentiated, and small outcrops of crystalline rock have been omitted. Furthermore, whereas the geologic map has all of the wells and springs listed in our well and spring data tables (Appendix A), the hydrogeologic map comprises only selected well and spring data points. Well data points on the latter map consist of all sites field-checked by GRC, plus the following. For the Detrital and Sacramento basins, all sites

with any reported water level measurements (generally post-1965) are included. For the Hualapai basin, the well data points include all of the sites on the 1980 Hualapai basin groundwater map by Remick (1981), and any additional sites with post-1975 reported water level measurements. Many of the sites on Remick's map have also been field-checked by GRC in 1982, or they have a more recent (1981 or 1982) water-level measurement reported by the U.S. Geological Survey (USGS). In either of these cases, both Remick's measurement and the more recent measurement are included on the hydrogeologic map. Spring data points on the hydrogeologic map consist of all springs field-checked by GRC, all springs on Remick's map, and all additional springs with a post-1975 altitude measurement reported by the USGS.

Data point symbols in the hydrogeologic map differentiate between wells and springs, sites field-checked by GRC and sites not field checked by GRC, and wells with alluvium versus those with crystalline or sedimentary rock as the producing formation. Information printed at each data point includes site number, water elevation, depth to water, date of measurement and site status. Equipotential contour lines, groundwater flow lines, and groundwater drainage divides are based on our interpretation of the hydrogeologic data. Surface drainage divides are based on the topography. A possible boundary between two discontinuous flow systems near Kingman and zones of possible bedrock faulting in the northern Sacramento Valley are also based upon our interpretation of the data.

Two general assumptions regarding groundwater flow in the alluvial valleys were made in accordance with the amount of available data and the regional scale at which this study has been done. The first assumption is that the change in groundwater levels with time is relatively small. That is, water level measurements from the 1960's to the 1980's are

consistent enough to justify drawing water level contour lines at 100 foot intervals based on the multi-year data. This assumption was necessary particularly for Detrital and Sacramento Valleys, where the spatial distribution of water level data for the 1980's is extremely sparse. The two areas where this assumption does not apply are the Hackberry Wash and Truxton Wash areas of Hualapai Valley.

The second assumption is that the alluvial aquifer in each of the valleys can be treated as a single, unconfined, permeable unit. The corollary to this assumption is that all wells penetrating the alluvium show water levels that are compatible with a single water table surface. This assumption and its corollary are appropriate on the regional scale at which this study has been done. That is, the available water level data are compatible within the framework of the 100 foot contour interval used on the hydrogeologic map. Of course, on a smaller, more detailed scale, the alluvial aquifers are better characterized as multi-layered systems, which include clay lenses and possibly extensive clay layers that act as leaky confining beds. Thus, locally one may find water level variations of a few tens of feet in wells perforated at different depths, probably because of leaky confining beds present in the alluvium. Nevertheless, on a regional scale, well log data are too sparse to accurately map the individual confining layers, and water-level data are too sparse to map out more than one potentiometric surface. Thus, because of the regional scale inherent to this study, it seems most appropriate to generally treat the alluvial aquifers as homogeneous units.

The source of recharge to the groundwater is ultimately precipitation. Storm runoff collects in stream channels, which drain from the mountains toward the valley centers. In the mountains where bedrock is close to the surface, groundwater is

recharged by surface water infiltrating beneath the alluvial stream beds, and then entering fractured, weathered or porous zones in the bedrock. Recharge to groundwater in the valley alluvium occurs mostly by surface water infiltration in the coarse alluvium beneath stream beds on the upper portions of the alluvial fans. Large volumes of this infiltrated water never reach the phreatic (saturated) zone of groundwater because they are lost to evapotranspiration. Nevertheless, a significant volume of water does pass beneath the root zone, from which evapotranspiration occurs, to recharge the extensive alluvial aquifers. Estimates of the annual volume of recharge to groundwater in Detrital and Hualapai Valleys are discussed in the appropriate sections of this chapter.

Recharge from precipitation that falls directly on the valley floors is negligible because of the high evapotranspiration rate and, according to Gillespie and Bentley (1971, p. 22), because relatively impermeable layers of clay and caliche near the land surface impede infiltration.

DETRITAL VALLEY

There are three parameters which are central to understanding a groundwater flow sytem, but for which data in Detrital Valley are almost entirely absent. These parameters are total thickness of the alluvium or basin-fill, the hydraulic properties of transmissivity and storativity for the aquifer, and multiple-year water level measurements. Because of these deficiencies in available data, it is very difficult to estimate useful parameters such as the total volume of groundwater in storage, the average annual volume of flow through the system, the safe yield of the aquifer (that is, the rate of groundwater consumption the aquifer can sustain without mining the resource), and long-term trends of groundwater level change. Our analysis of groundwater in the Detrital Valley has been limited because of these data deficiencies.

Table 2 contains a summary of wells in the alluvium beneath Detrital Valley. All of the data in this table are condensed from data in the well data table (Appendix A). The only column in Table 2 for which entries differ from those in Appendix A is the column labeled "Producing Formation Confirmed by Driller's Report." In Table 2, the "Alluv" entry in this column appears only for those wells for which driller's reports are availalbe to confirm the material penetrated by the well. (In contrast, wells in Appendix A with entries in the "Producing Formation" column may or may not have driller's reports available. The meaning of entries in this column in Appendix A is discussed in the explanation at the beginning of the appendix). The wells in Table 2 are divided into four groups which represent clusters of wells as they occur on the hydrogeologic map. The well groups are numbered I through IV, progressing from north to south.

Groundwater flow in the Detrital Valley generally parallels the surface flow, draining from the mountains toward the valley center, and then north toward the Colorado River at Lake Mead. A groundwater drainage divide roughly coincides with the surface drainage divide at the southern end of Detrital Valley. The hydraulic gradient is apparently steepest in the Dolan Springs area (well group IV; in T25N and T26N, R19W) where groundwater descends steeply out of a relatively narrow, yet moderately deep, alluvial channel between bedrock outcrops. The gradient here is .044 foot per foot. Following the drainage west and then north, the gradient flattens out to as little as .001 foot per foot north of the 2000 foot contour line, in the northern part of the valley.

The data in Table 2 pertaining to alluvium thickness may be summarized as follows. Where a driller's report indicates that a well is drilled entirely within alluvium (as indicated by an "Alluv" entry in the last column of Table 2), one can infer that the total alluvium thickness is at least as great as

Table 2: SUMMARY OF WELLS IN DETRITAL VALLEY ALLUVIUM

Group	Site No.	Well Depth (feet)	Water Level (feet)	Water Use*	Discharge (gpm)	Drawdown (feet)	Producing Formation Confirmed by Driller's Report
Group I (Northern basin)	29-21 35CCC	250	38	S	22	--	--
	28-21 3ABB	1300	--	N	22	400	NOTE: Unreliable data source for this well
	28-21 20AAC	385	303	S	100	--	Alluv
	28-21 26BBD	500	218	N	29	--	--
Group II (Central basin)	27-21 14CCD	262	Dry	U	--	--	--
	27-21 24BBB	79	Dry	U	--	--	--
	27-21 24BDC	460	397	N	125	--	Alluv
	27-21 24CDD	464	423	H	33	0	Alluv
	27-21 25BAA	470	440	H	19	0	--
	27-21 25DDC	400(?)	435(?)	S,H	8 and 7	0	--
Group III (South-central basin)	25-20 15AAA	1100	599	S	--	--	--
	25-20 15DAD	730	629	H	--	--	--
	25-19 17CDD	840	770	H, U	--	--	Alluv
	25-19 29DCB	436	Dry	U	--	--	--
	25-19 30BBA	--	705	H	--	--	Alluv
	25-19 30BAD	825	>669	U	--	--	--
	25-19 30AAA	955	738	H	58.3	--	Alluv
	25-19 31AAA	880	788	U	--	--	Alluv
	24-19 8AAD	50	Dry	U	--	--	--
Group IV (Dolan Springs area)	26-19 35DDA	480	330	P	100	0	--
	26-19 36CCB	500	348	P	83	0	Alluv
	25-19 1BAB	600	410	P	53	142	Alluv
	25-19 1BDA	525	399	H	40-50(?)	--	--
	25-19 3CCC	715	588	H	128	--	Alluv
	25-19 11CBD	700	615	H	--	--	Alluv

* Water use symbols are defined in the explanation in Appendix A.

the depth of the well. Thus, the alluvium thickness is at least 600 feet northeast of Dolan Springs (well group IV), 715 feet at Dolan Springs (well group IV), and 955 feet in the south-central Detrital basin (well group III). The alluvium thickness is at least 423 feet in the central portion of the basin (well group II) and 385 feet in the northern portion of the basin (well group I). (As discussed in the basins section of Chapter 4, the combined alluvium and bedded salt deposits in the far northern portion of Detrital Valley, near and just outside of the study area boundary, are at least 1,000 feet thick.)

Information pertaining to depth to water, well yields and water use may also be summarized from data in Table 2. In general, the depth to water increases from the area northeast of Dolan Springs down gradient to the south-central Detrital basin. The depth to water ranges from 330 to 410 feet northeast of Dolan Springs, from 588 to 615 feet at Dolan Springs, and from 599 to 788 feet in the south-central basin. Proceeding downgradient from the south-central basin, the depth to water decreases. It ranges from 397 to 440 feet in the central basin, and from 218 and 303 feet in the northern basin to 38 feet at the data point farthest north. Well yields throughout Detrital Valley range from about ten to 130 gallons per minute. The greatest concentration of the higher producing wells occurs in the group IV, Dolan Springs area where the water is used for municipal and domestic supplies for the town of Dolan Springs. Water pumped in all the other areas of Detrital Valley is used either for domestic supply, stockwatering, or temporary construction work on Highway 93. Although the data are insufficient for an accurate count of total average annual groundwater consumption in Detrital Valley, we estimate that the average total consumption is probably less than 300 gallons per minute, or 500 acre-feet per year (af/yr).

The water level data are inadequate to draw any

conclusions about persistent trends of water level change in Detrital Valley. Only one well in the entire valley has water level measurements for more than one year. That well is 25-19 30aaa, and the pertinent data are as follows:

Year	Groundwater Elevation	Reporting Source
1966	2235	USGS; apparently driller was original source
1979	2261	Owner

If the data are accurate, a 26 foot rise in 13 years is indicated. However, considering that there is only one data point with only two measurements, and that the reliability of reported measurments is variable, we do not draw any conclusion from this data. We assume, until additional data prove otherwise, that Detrital Valley groundwater levels are at approximately steady-state.

In order to derive an estimate for the annual volume of groundwater outflow from Detrital Valley, computations based on Darcy's Law were made for two cross-sections through the valley. Darcy's Law states:

$$Q = K\ b\ L\ I$$

where: Q = groundwater flow rate in gallons per day

K = hydraulic conductivity in gallons per day per square foot

b = saturated thickness of the aquifer in feet

L = length of cross-section perpendicular to flow in feet

I = hydraulic gradient (dimensionless).

Gillespie and Bentley (1971, p.23-25) estimated hydraulic conductivity for the older alluvium in both Hualapai and Sacramento Valleys to range from 60 to 90 gallons per day per

square foot. In lieu of data specific to Detrital Valley, we assume that the hydraulic conductivity of the older alluvium in the Detrital basin is approximately equal to that estimated by Gillespie and Bentley for the two adjacent basins. For the computations, we assume that the alluvium thickness beneath the valley is at least 1000 feet. The minimum saturated thickness of the aquifer at each cross-section is then computed by subtracting the known depth to water in the area from 1000 feet.

One of the cross-sections used for our computations crosses the northern portion of Detrital Valley through well (29-21) 35ccc. For this section, the hydraulic gradient is .001 foot per foot, measured from the hydrogeologic map between the 2000 foot equipotential line and well 35ccc. The length of this cross-section (adjusted to represent the length of section for which the alluvium thickness is at least 1000 feet) is 6 miles or 31,680 feet. The second cross-section passes through the middle of the valley at about the 2100 foot equipotential line. For the latter section, the hydraulic gradient is .0042 foot per foot, measured from the hydrogeologic map between the 2200 foot and 2000 foot equipotential lines. The length of this cross-section (adjusted as described above) is 2.5 miles or 13,200 feet.

By applying Darcy's Law with the parameters discussed above, we estimate that the minimum rate of groundwater outflow from Detrital Valley is on the order of 1.9 to 3.0 million gallons per day, or 2,100 to 3,400 af/yr. Because the total alluvium thickness could be much greater than the 1000 foot value we used above, we believe that the groundwater flow rates derived represent minimum likely rates. We emphasize that, because of the uncertainty of the data, these outflow values are order-of-magnitude estimates only.

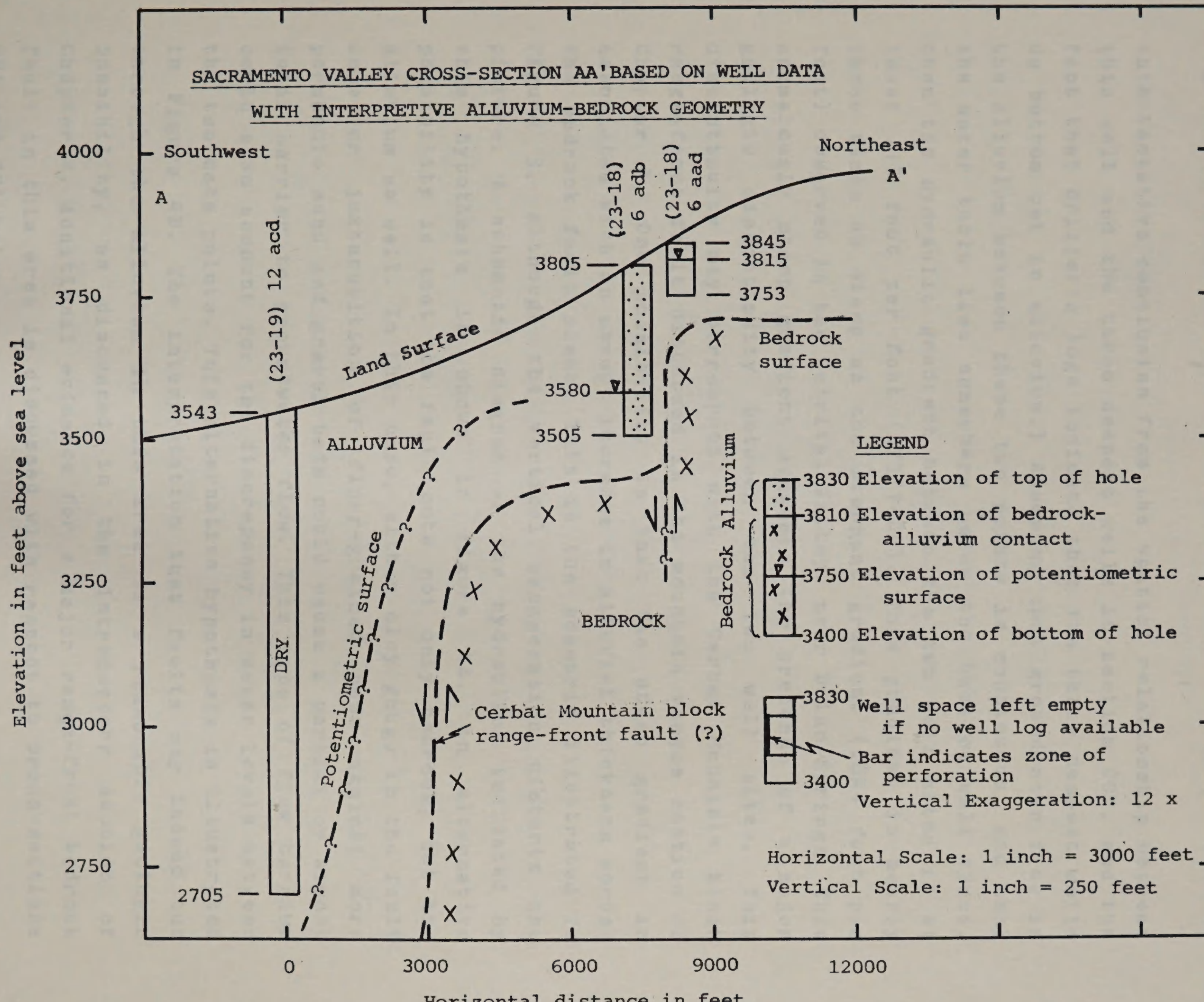
The water balance equation states that "Total Inflow + Decrease in Groundwater Storage = Total Outflow + Consumptive

Use." Because we assume that Detrital Valley water levels are at approximately steady-state, it follows that none of the total flow through the system is coming out of groundwater storage. We estimate above that average annual groundwater consumption in Detrital Valley is probably less than 500 af/yr. Thus, with decrease in groundwater storage effectively zero, the total groundwater inflow to Detrital Valley equals the total groundwater outflow plus about 500 af/yr (or less) of consumptive use. We have estimated the minimum total groundwater outflow from Detrital Valley to be on the order of 2,100 to 3,400 af/yr. As a result of our water balance, we estimate the minimum likely annual groundwater recharge to Detrital Valley to be approximately 2,600 to 3,900 af/yr.

NORTHERN SACRAMENTO VALLEY

In general, groundwater flow in the Sacramento Valley parallels the surface flow, draining from the mountains toward the valley center, then south, and finally west, toward the Colorado River. However, in the northern end of Sacramento Valley, the available well data indicate that the flow system is more complex than the simple, general pattern described above. Our analysis of these well data is illustrated on the hydrogeologic map and in three interpretive cross-sections traversing northern Sacramento Valley. The cross-sections appear in Figures 3, 5 and 6. The lines of section are shown on the hydrogeologic map.

In section AA' (Figure 3) there are two hydrologic features of interest. The first feature is the discrepancy in water levels between wells (23-19) 12acd and (23-18) 6adb. Well 6adb shows groundwater in alluvium at an elevation of 3580 feet. In contrast, well 12acd, which lies approximately 7400 feet to the southwest and which bottoms out at an elevation of 2705 feet, is dry. (Although no well log for well 12acd is available, the well probably bottoms out in alluvium. We draw



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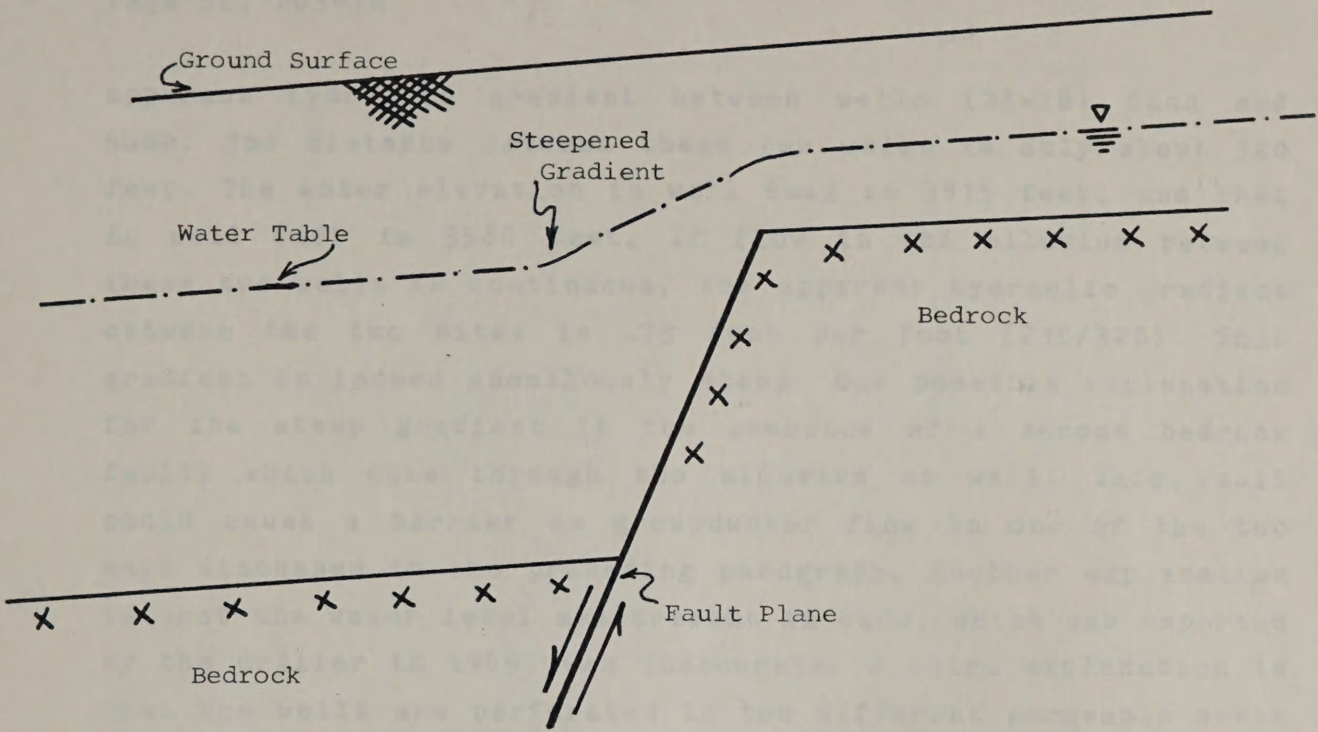
CROSS-SECTION AA'

FIGURE 3

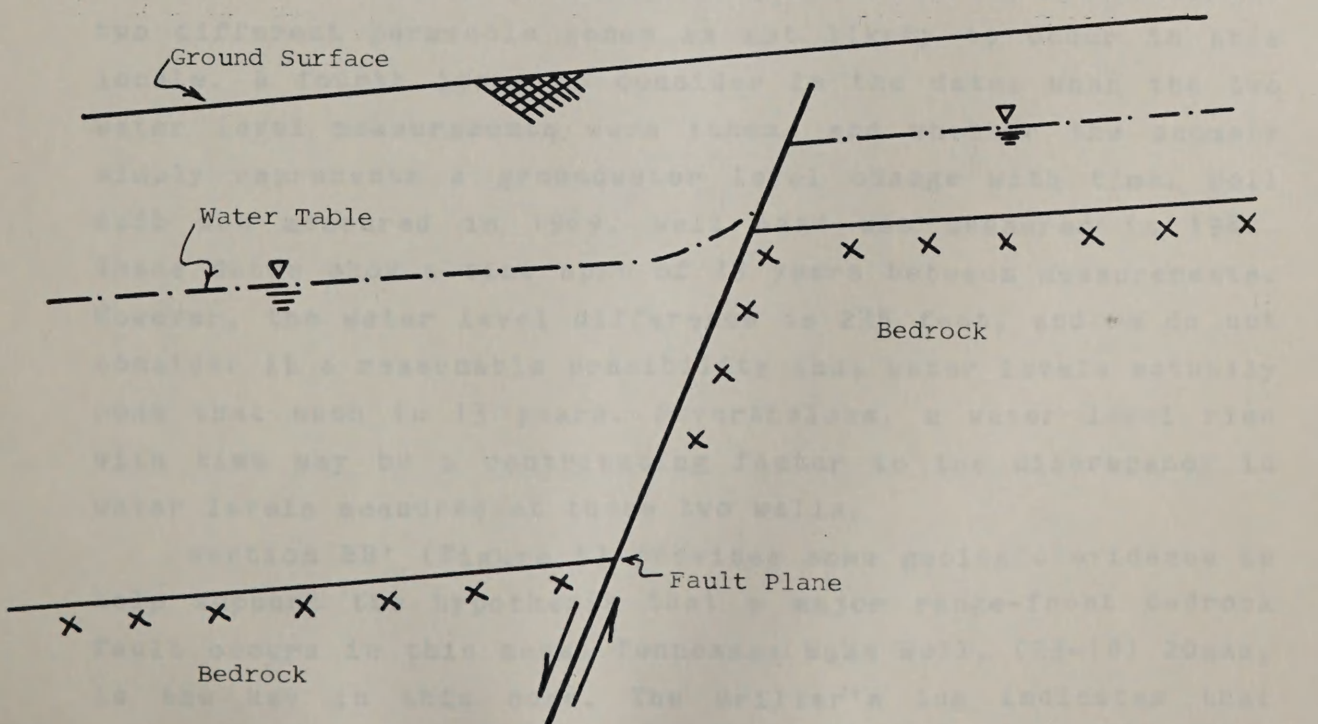
this tentative conclusion from the spatial relationship between this well and the three deepest wells in section CC', and the fact that driller's logs indicate that the three deepest wells do bottom out in alluvium.) Assuming that groundwater flow in the alluvium between these two points is continuous, and that the water table lies somewhere below the base of well 12acd, then the hydraulic gradient between the two well sites is at least .12 foot per foot (875/7400). This gradient is nearly three times as steep as the steepest gradient (.044 foot per foot) observed in the Detrital Valley, near Dolan Springs. This anomalously steep gradient suggests the presence of a major geologic discontinuity between the two well sites. This discontinuity may correspond with the Cerbat Mountain block range-front fault discussed in the mountain ranges section of Chapter 4. One possibility is that the steep gradient is associated with an abrupt increase in alluvial thickness across the bedrock fault plane. This is the scenario illustrated in Figure 3, although the vertical exaggeration distorts the picture. A schematic diagram of the hydraulics indicated by this hypothesis is shown in Figure 4A. An alternative possibility is that the fault cuts not only bedrock, but the alluvium as well. In this case, either clay gouge in the fault zone or juxtaposition of finer-grained beds against more permeable sand and gravel beds could cause a partial or almost total barrier to groundwater flow. This type of flow barrier could also account for the discrepancy in water levels between the two data points. This alternative hypothesis is illustrated in Figure 4B. The interpretation that faults may indeed cut through the alluvium in this area is a reasonable geologic possibility, as discussed in the introductory section of Chapter 4. Additional evidence for a major range-front bedrock fault in this area is discussed with respect to cross-sections BB' and CC' below.

The second feature of interest in section AA' is the

A. STEEP HYDRAULIC GRADIENT ASSOCIATED WITH BEDROCK FAULT PLANE



B. FLOW BARRIER ASSOCIATED WITH FAULT THAT EXTENDS THROUGH ALLUVIUM



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SCHEMATIC CROSS-SECTIONS SHOWING ALTERNATIVE EXPLANATIONS FOR STEEP HYDRAULIC GRADIENT

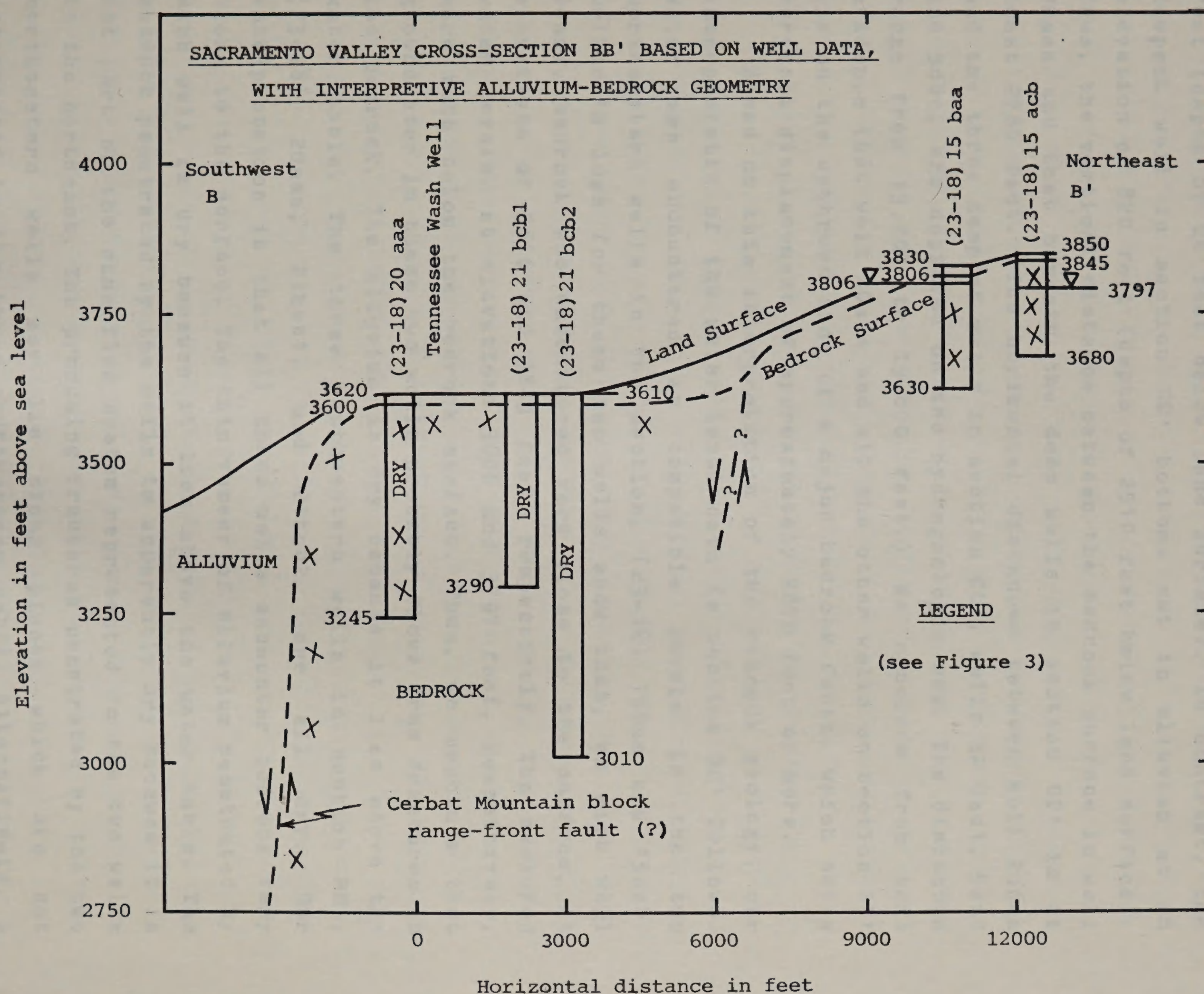
FIGURE 4

apparent hydraulic gradient between wells (23-18) 6aad and 6adb. The distance between these two wells is only about 320 feet. The water elevation in well 6aad is 3815 feet, and that in well 6adb is 3580 feet. If flow in the alluvium between these two wells is continuous, the apparent hydraulic gradient between the two sites is .73 foot per foot (235/320). This gradient is indeed anomalously steep. One possible explanation for the steep gradient is the presence of a second bedrock fault, which cuts through the alluvium as well. This fault could cause a barrier to groundwater flow in one of the two ways discussed in the preceding paragraph. Another explanation is that the water level measurement in 6adb, which was reported by the driller in 1969, was inaccurate. A third explanation is that the wells are perforated in two different permeable zones separated by a confining bed. However, where these two wells are located on the upper portion of an alluvial fan, one would expect to find mostly very coarse-grained material. A confining bed impervious enough to effectively separate the hydraulics of two different permeable zones is not likely to occur in this locale. A fourth issue to consider is the dates when the two water level measurements were taken, and whether the anomaly simply represents a groundwater level change with time. Well 6adb was measured in 1969. Well 6aad was measured in 1982. These dates show a time span of 13 years between measurements. However, the water level difference is 235 feet, and we do not consider it a reasonable possibility that water levels actually rose that much in 13 years. Nevertheless, a water level rise with time may be a contributing factor to the discrepancy in water levels measured at these two wells.

Section BB' (Figure 5) provides some geologic evidence to help support the hypothesis that a major range-front bedrock fault occurs in this area. Tennessee Wash Well, (23-18) 20aaa, is the key in this case. The driller's log indicates that bedrock was encountered in this well at an elevation of 3600

apparent hydraulic gradient between wells (23-16) 5aad and 5adb. The distance between these two wells is only about 120 feet. The water elevation in well 5aad is 3815 feet, and that in well 5adb is 3580 feet. If flow in the alluvium between these two wells is continuous, the apparent hydraulic gradient between the two sites is [illegible] foot per foot (235/120). This gradient is [illegible] unusually steep. One possible explanation for the steep gradient is the presence of a second bedrock fault, which cuts through the alluvium as well. This fault would serve as a barrier to groundwater flow as one of the two were discussed in the preceding paragraph. Another explanation is that the water level measurement in 5adb, which was reported by the driller in 1969, was inaccurate. A third explanation is that the wells are perforated in two different permeable zones separated by a confining bed. However, where these two wells are located at the upper portion of an alluvial fan, one would expect to find mostly very coarse-grained material. A confining bed impervious enough to effectively separate the hydraulics of two different permeable zones is not likely to occur in this locale. A fourth issue to consider is the dates when the two water level measurements were taken, and whether the anomaly might represent a groundwater level change with time. Well 5adb was measured in 1969. Well 5aad was measured in 1982. These dates show a time span of 13 years between measurements. However, the water level difference is 235 feet, and we do not consider it a reasonable possibility that water levels actually rose that much in 13 years. Nevertheless, a water level rise with time may be a contributing factor to the discrepancy in water levels measured at these two wells.

Section 8E (Figure 3) provides some geologic evidence to help support the hypothesis that a major range-front bedrock fault occurs in this area. Tennessee Gas Well, (23-16) 20aaa, is the key in this case. The driller's log indicates that bedrock was encountered in this well at an elevation of 3600



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CROSS-SECTION BB'

FIGURE 5

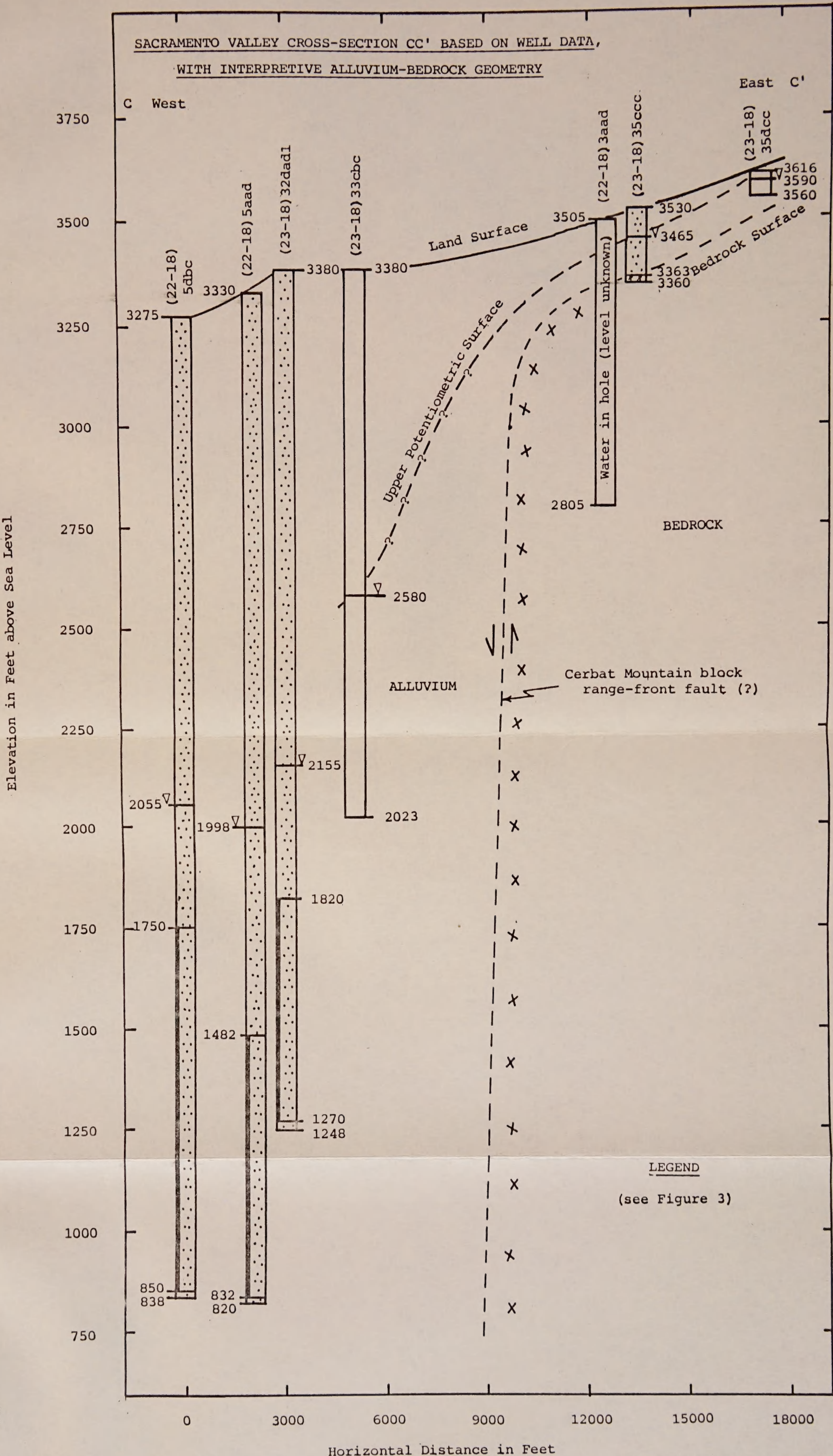
feet (depth of 20 feet below land surface). In contrast, the deepest well in section CC' bottoms out in alluvium at an elevation of 820 feet (depth of 2510 feet below land surface). Thus, the vertical distance between the bedrock surface in well 20aaa and that beneath the deep wells in section CC' is at least 2780 feet. (The horizontal distances between well 20aaa and the three deepest wells in section CC', wells 32 dad1, 5aad and 5dbc, are depicted on the hydrogeologic map. The distances range from 13,200 to 19,800 feet.) We conclude from this evidence that well 20aaa and all the other wells on section BB' lie on the upthrown side of a major bedrock fault, which has a vertical displacement of approximately 2800 feet or more.

Based on this interpretation of the bedrock geology, our interpretatin of the water level data in section BB' follows. Water was encountered at compatible levels in the two northeastern wells in the section, (23-18) 15baa and 15acb. Driller's logs for these two wells show that, as with well 20aaa, bedrock was encountered very close to the surface, at elevations of 3816 and 3845 feet, respectively. The measured water levels, at elevations 3806 and 3797 feet, respectively, were both below the bedrock surface. Thus, we conclude that groundwater in these two wells probably flows from fractures in the bedrock. The alluvium is dry because it lies above the water table. The three southwestern wells in section BB', (23-18) 20aaa, 21bcb1, and 21bcb2, are all dry. Our interpretation is that all three wells encounter bedrock very close to the surface. The thin veneer of alluvium penetrated by each well is dry because it lies above the water table. The bedrock penetrated by the wells is apparently dry because it is not part of the same flow system represented in the two wells to the northeast. The producing fractures penetrated by the two northeastern wells may lie along planes which are not intersected by the three southwestern wells. Alternatively, a fracture or fault zone in the bedrock between these two groups

of wells may be filled with impermeable material, and thus, create a barrier to groundwater movement. If a fracture zone such as this exists, it may be an extension of the secondary fault zone postulated in section AA'.

Section CC' (Figure 6) shows both geologic and hydrologic evidence suggestive of a major range-front fault on the west side of the Cerbat Mountains. The geologic evidence involves three very deep wells to the west, (22-18) 5dbc and 5aad, and (23-18) 32dad1, and one shallow well to the east, (23-18) 35ccc. Driller's logs indicate that the three deep wells penetrate alluvium all the way down. The deepest of these holes, well 5aad, bottoms out in alluvium at an elevation of 820 feet. In contrast, the driller's log for the shallow well, 35ccc, indicates that bedrock was encountered at an elevation of 3363 feet. In this case, the vertical distance between the bedrock surface in well 35ccc and that beneath the base of well 5aad is at least 2543 feet. We infer from this evidence that the three deep wells lie on the downthrown side and well 35ccc lies on the upthrown side of a major bedrock fault. The vertical displacement along the fault must be at least 2500 feet according to section CC'. As discussed above, well data on section BB', in conjunction with those on section CC', suggest a vertical displacement of at least 2800 feet.

The hydrologic evidence on section CC' that supports the theory of a major bedrock fault involves the hydraulic gradient between well (23-18) 35ccc on the east and well 33cbc on the west. The groundwater elevation in well 35ccc is 3465 feet, and that in well 33cbc is 2580 feet. The horizontal distance between the two wells is about 10,600 feet. Although no well log for well 33cbc is available, we presume the well penetrates alluvium all the way down because of its proximity to the deep wells known to bottom out in alluvium. Thus, it seems that groundwater flow in the alluvium between wells 35ccc and 33cbc could well be continuous. The hydraulic gradient indicated



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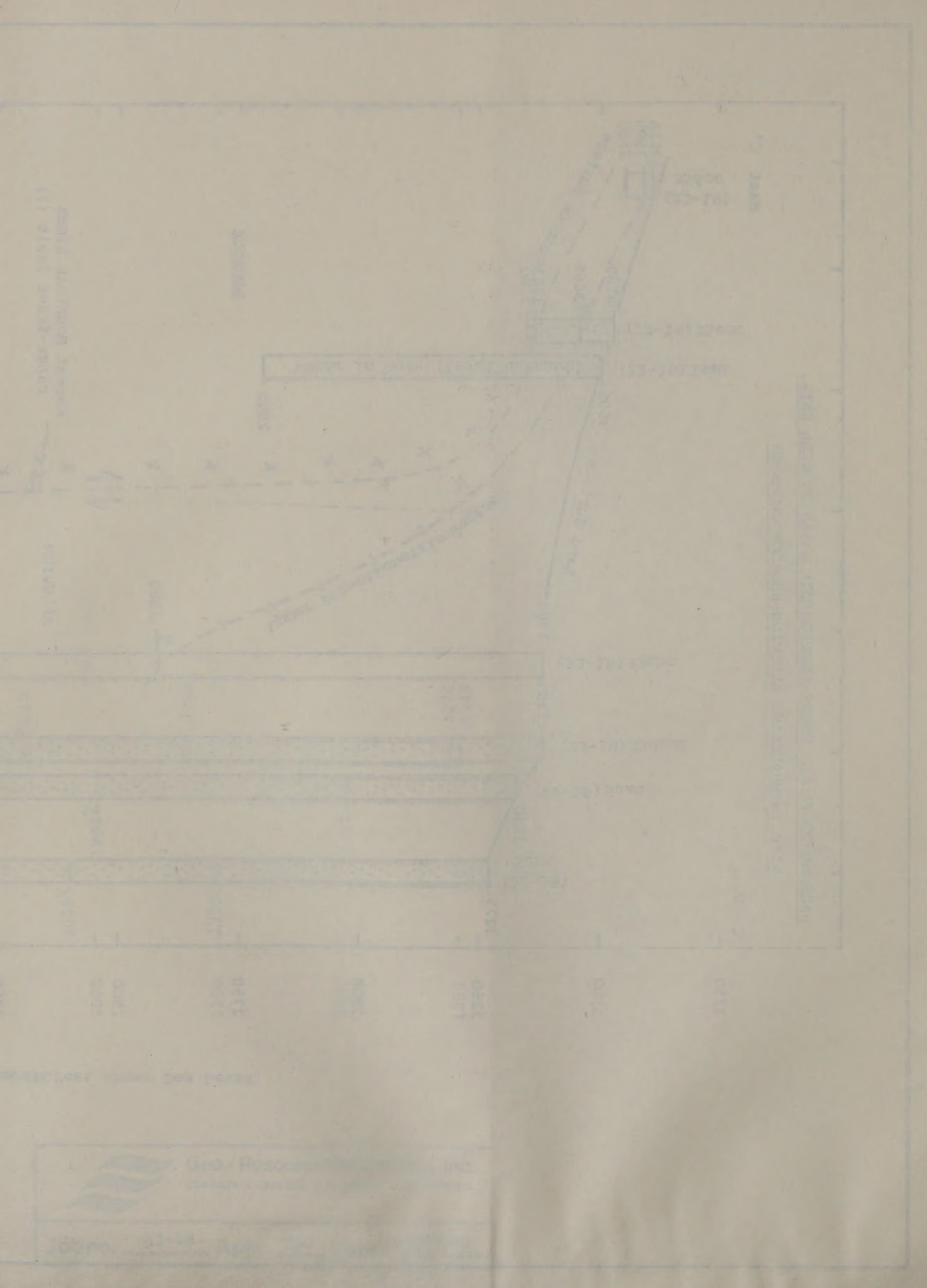
CROSS-SECTION CC'

FIGURE 6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is .08 foot per foot (885/10,600). This gradient is nearly twice as steep as the steepest gradient (.044 foot per foot) in Detrital Valley, near Dolan Springs. Thus, we conclude once again, on the basis of an anomalously steep hydraulic gradient, that a major bedrock fault may lie between the two points of concern. The steep gradient could be associated wth an abrupt increase in alluvial thickness across the bedrock fault plane, similar to that postulated in section AA' and illustrated schematically in Figure 4A. This also is the scenario illustrated in Figure 6, although the vertical exaggeration again distorts the picture. Alternatively, the fault may cut the alluvium as well as the bedrock, as illustrated schematically in Figure 4B. In this case, a flow barrier caused by clay gouge in the fault zone or the juxtaposition of finer-grained beds against coarser-grained beds could account for the discrepancy in water levels on opposite sides of the fault.

There is one other phenomenon of interest in section CC'. Of the four wells west of the fault, the water level in 33cbc is remarkably higher than that in the other three wells. Our explanation is as follows. The three deeper wells, which also have the deeper water levels, are all perforated through elevation ranges that begin beneath the base of well 33cbc. Thus, the three deep wells are tapping alluvial strata far below those tapped by well 33cbc. We propose that the discrepancies in water levels are due to inhomogeneities in the alluvium. Apparently confining beds do separate permeable beds whose hydraulics are more or less disconnected from each other. Thus, the potentiometric surface or surfaces represented in the three deeper wells are not continuous with that in well 33cbc. Note that the 2600 foot equipotential line drawn on the hydrogeologic map represents the upper potentiometric surface, as appears in well 33cbc. At least one deeper piezometric surface, at around 2000 to 2100 feet in elevation, also occurs

in this area, as represented in the three deeper wells.

Additional information drawn from the well data in northern Sacramento Valley may be summarized as follows. The depth to water is highly variable, as illustrated on the three cross-sections discussed above. Recorded well yields are generally 30 gallons per minute (gpm) or less. The only three wells with recorded yields greater than 30 gpm are (23-18) 32dad1 (yield 150 gpm), which is one of the deep wells on section CC'; and (23-18) 15baa and 15acb (yields 70 gpm and 100 gpm, respectively), which are the two wells apparently producing from fractures in bedrock in section BB'. However, none of these three wells are currently in use. A large volume of the groundwater pumped in the area is used for the municipal water supply for the town of Chloride. Five municipal supply wells, each yielding 15 gpm, lie in township 23 north, range 18 west, sections 3 and 4. Well (24-18) 34cab is a sixth municipal supply well, also yielding 15 gpm. Groundwater in the area is also used for stockwatering, domestic supplies and small mining operations. The water level data are insufficient for us to draw any conclusions regarding trends of groundwater level change with time.

<u>HUALAPAI VALLEY</u>

Although the surface drainage in Hualapai Valley is internal, groundwater flow exits the drainage basin both to the north and to the south. Most of the groundwater movement runs from the mountains toward the valley center, and then north, beneath Hualapai Wash, to discharge into the Colorado River at Lake Mead. A secondary outlet from the Hualapai basin occurs in the Hackberry area. Some of the groundwater from Truxton Canyon turns south, flowing against the topographic gradient, and toward Big Sandy Valley, which lies southeast of the study area. The groundwater drainage divide, which lies well north of the surface drainage divide in this area, occurs near the mouth

of Truxton Canyon. The location of this groundwater divide has changed with time. Under natural conditions prior to significant pumping interference, it lay further south, although still north of the topographic divide (Gillespie and Bentley, 1971, p. 22). However, pumping in the Hackberry area has pushed the groundwater divide north to its present position. Hydraulic gradients in the Hualapai basin range from as high as .023 foot per foot beneath Truxton Wash and .012 foot per foot in the tributary canyon south of Table Montain Plateau, to .001 foot per foot in the central part of the main basin.

The depth to water beneath Hualapai Valley ranges from approximately 500 to 900 feet northeast of Kingman, down to about 260 to 300 feet south of Red Lake. From Red Lake north to the topographic divide, the depth to water increases from approximately 350 feet to 650 feet at well (28-17) 31ccc. Beneath Truxton Wash, the depth to water ranges from about 20 feet at the mouth of Truxton Canyon to about 600 feet at well (24-14)29aaa. Beneath Hackberry Wash the depth to water ranges from approximately 200 feet to 500 feet, moving downgradient.

Well yields in the main Hualapai basin range from 10 gpm for domestic wells to 1600 gpm for irrigation and municipal wells, especially near Kingman and Valle Vista. Wells near Red Lake have produced as much as 2200 and 3000 gpm, although these wells are not currently in use. Recorded well yields in the Truxton Wash-Hackberry area range from 5 to 430 gpm. The higher producing wells are used for irrigation and Kingman municipal water supply. Gillespie and Bentley (1971, p. 23, 25, 26) briefly discuss the history of well use and groundwater consumption rates in Hualapai Valley. According to Remick (1981) groundwater consumption in the Hualapai basin has increased from less than 500 acre-feet per year (af/yr) in 1960, to 4000 af/yr in 1967, to 6000 af/yr for 1978 through 1980.

Remick (1981) indicates that the well field in the Truxton Wash-Hackberry area was developed in 1943 and used through 1945 as a water supply for the Army Air Base near Kingman during World War II. From 1960 to 1969, the well field was used for a municipal water supply for the City of Kingman. According to Remick, well yields in this area ranged from 200 to 1200 gpm, the higher yield wells producing from in or near Truxton Wash, during these two periods of high use.

On the basis of discharge and drawdown data, Gillespie and Bentley (1971, p. 23-25) estimated values for the transmissivity and hydraulic conductivity of the older alluvium beneath Hualapai Valley. Transmississivity is the product of hydraulic conductivity and the saturated thickness of the aquifer. In the main Hualapai basin, the estimated hydraulic conductivity was 60 gallons per day per square foot. The transmissivity estimates ranged from 34,000 to 44,000 gallons per day per foot (gpd/ft). In the Hackberry area, the estimated hydraulic conductivity at well (23-13) 20ccd was 90 gallons per day square foot, and the estimated transmissivity was 22,000 gpd/ft. Some additional figures for transmissivity near Red Lake were quoted from Van der Harst (1980) by Remick (1981). These transmissivity values ranged from 2,100 to 27,000 gpd/ft.

Both Gillespie and Bentley (1971, p. 27) and Remick (1981) computed estimates of subsurface outflow from the Hualapai basin using Darcy's Law (as we have done above for Detrital Valley). Gillespie and Bentley conclude that the groundwater outflow north of Red Lake is 4,000 af/yr, and the outflow southeast of Hackberry is 1,000 af/yr. Thus, the total subsurface outflow from the basin is 5,000 af/yr. Remick's estimates indicate 2,000 to 2,500 af/yr of outflow north of Red Lake, and 400 to 1,300 af/yr of outflow southeast of Hackberry. Thus the total subsurface outflow estimated by Remick would range from 2,400 to 3,800 af/yr.

Estimates for the average annual recharge to the Hualapai

groundwater basin have also been proposed by both Remick (1982) and Gillespie and Bentley (1971, p. 22). Gillespie and Bentley indicate that, except in the Hackberry area, natural conditions, in which long-term groundwater recharge equals subsurface outflow, probably have not been affected by pumping. Thus, they imply that the annual groundwater recharge is approximately equal to the discharge at the basin boundaries, which they estimated to be 5,000 af/yr. In contrast, Remick estimates an annual groundwater recharge rate of 8,000 to 12,000 af/yr. We point out that if the groundwater consumption from 1967 onward ranged from 4,000 to 6,000 af/yr, as indicated by Remick, then the annual recharge must be at least as high as Remick estimates in order for groundwater levels to have dropped as little as they apparently have.

The following discussion of groundwater level changes with time is based on our analysis of water level monitoring data provided by the U.S. Geological Survey (Water Resources Division, Phoenix, Arizona). We point out that, although small to moderate water level fluctuations have been observed, none of these are great enough to significantly change the positions of equipotential contour lines at 100 foot intervals across the Hualapai Valley. In accordance with this statement, the Hualapai basin groundwater contour maps by both Remick (1981) and Gillespie and Bentley (1971, Plate 1) show a distribution of equipotential lines very similar to that on our hydrogeologic map. A discussion of the small to moderate water level fluctuations that have, nonetheless, been observed follows.

In the main Hualapai basin from Red Lake north, a one to five foot rise in water levels from 1965 to 1980 is indicated. In the main basin from Red Lake to south of Long Mountain, no persistent trends have been observed. Northeast of Kingman, in the southern portion of the main basin, a water-level decline of about five feet from 1965 to 1982 is suggested.

The only area with really major groundwater level declines is apparently the Truxton Wash-Hackberry area. Water level data for this area often date back to the early 1940's. The data are complex, and even the seasonal water level fluctuations are sometimes large (16 and 27 feet), presumably because of the effect of high pumpage in the area. Nevertheless, the overall trend is certainly a decline, ranging from about 20 to 75 feet from the early 1940's to 1980. Beneath Hackberry Wash, the water level decline during this interval ranged from 38 to 61 feet. Beneath the upper portion of Truxton Wash, declines in four wells ranged from 24 to 76 feet during that same time interval. However, three other wells show declines of up to 51 feet from the early 1940's to 1965, and then a groundwater rise of 7 to 57 feet from 1965 to 1980. These contrasting trends in the upper Truxton Wash may be a function of inhomogeneities in the alluvium and wells perforated at different depths. Alternatively, they may reflect that the water level data in this area are affected by the high pumpage and therefore cannot be interpreted at face value. Beneath the lower portion of Truxton Wash (in T24N, R14W), three wells show groundwater declines of 23 to 48 feet from the early 1940's to 1980. However, a fourth well in the area shows a similar trend to wells discussed above. Groundwater in this well dropped over 35 feet from the early 1940's to 1965, and then it rose over 11 feet from 1965 to 1980. We propose a similar explanation to that discussed above for the water level fluctuation in this well.

Gillespie and Bentley (1971, p. 28-29) also discuss water level fluctuations in Hualapai Valley. They indicate that in the main part of Hualapai Valley, water levels have remained almost unchanged, except for slight fluctuations due to barometric effects. In the Truxton Wash-Hackberry area, water levels have declined at rates ranging from half a foot to seven feet per year from about 1950 to the late 1960's.

KINGMAN AREA

The general occurrence of groundwater in the younger volcanic rocks near Kingman, as indicated by Gillespie and Bentley (1971), is discussed above in the stratigraphic units section of Chapter 4.

Gillespie and Bentley (1971, p. 25-27, 29) also give some history about well development and use in the area. In summary, over 100 domestic and public-supply wells have been drilled in the younger volcanics near Kingman. Prior to 1961, nearly 250 af/yr was pumped from these wells, mostly for the Kingman municipal water supply. In 1961 this pumpage decreased to about 130 af/yr because an additional Kingman water supply was developed in the Truxton Wash-Hackberry area of Hualapai Valley. As of the time of Gillespie and Bentley's report (1971), only 20 of the wells in the younger volcanics were still in use. The municipal wells among them each yield about 100 gpm. A decline of water levels of about one foot per year was observed from 1953 to 1963. From 1963 on, the groundwater has risen at about a half foot per year in response to the decreased Kingman municipal pumpage from the volcanic rocks.

Our interpretation of groundwater flow in the younger volcanics near Kingman is illustrated on the hydrogeologic map. Apparently there are at least two discontinuous flow systems represented by the well data. The dash-dot line indicates the boundary between the two systems. North of the boundary, groundwater flows southeastward down a steep gradient of about .04 foot per foot. The volcanic strata in this area also dip to the southeast (Gillespie and Bentley, 1971, Plate 1). Therefore, we suggest that the groundwater in this system may come from a particular permeable interbed of agglomerate or gravel in the volcanic strata. Note that recorded depths of all the wells in this area fall within a reasonably narrow range of 60 to 140 feet.

In three wells south of the discontinuity boundary, water

elevations are about 300 feet lower than those in wells just north of the boundary. In contrast to the northern wells, the southern wells are all 300 feet deep or more. According to the driller's report, one of the wells is screened from a depth of 220 to 300 feet. Driller's reports for two of the southern wells indicate that during drilling no water was encountered at elevations higher than the current static water levels. This evidence all suggests that there is some kind of geologic boundary, possibly a fault, which creates a barrier to groundwater movement. This boundary separates the flow system represented in the northern wells from that in the southern three wells. South of this boundary, the hydrologic data provided by the three wells are insufficient to determine a general pattern of groundwater flow.

Even further south than the three southern wells discussed above lies a cluster of three more wells, just outside the project area boundary. Water levels in this cluster of wells are 200 feet lower than those in the "southern" wells discussed above. We suggest that these three wells represent a different flow system from that of any of the wells in the younger volcanics discussed above. The three wells are apparently drilled into an alluvial channel leading southwest to Sacramento Valley.

BLACK MOUNTAINS, CERBAT MOUNTAINS, WHITE HILLS AND GRAND WASH CLIFFS

In the mountain areas, groundwater occurs in fractured and weathered zones of the Precambrian igneous and metamorphic rocks, fractures and solution channels in the Paleozoic sedimentary rocks, and fractures and tuff beds in the volcanic rocks. No attempt was made to contour water levels in these rocks because flow patterns in fractured rock are localized and complex, and the scattered well and spring data available are inadequate for a detailed analysis of these complex systems.

In general, where wells have encountered water, the yields are small, usually less than 30 gpm. The depths to water are variable, although most producing wells in bedrock in the Black Mountains, Cerbat Mountains and White Hills encounter water at less than 100 feet. In the Paleozoic sedimentary rocks capping the Grand Wash Cliffs, the depth to water in wells is as great as several hundred feet. Many small springs issue from bedrock in the mountains. Spring yields measured by GRC in the field were generally less than 6 gpm.

In the White Hills, groundwater occurs not only in fractured or weathered bedrock, but also in pockets of alluvium that are quite deep and extensive relative to most occurrences of alluvium in the mountains. The aerial extent of these alluvial deposits is illustrated on both the geologic and hydrogeologic maps (Plates 1 and 3). Some information regarding depths of the deposits is provided by driller's reports. Driller's reports indicate that well (26-18)5dbb bottomed out in alluvium at a depth of 700 feet, and well (28-19)25abb bottomed out in alluvium at a depth of 375 feet. The data from these two wells indicate that the alluvium is at least 700 and 375 feet deep, respectively, in each of the alluvial pockets represented. Our interpretation is that the geology in the White Hills is very complex, possibly with many bedrock faults which create bedrock outcrops separated by small alluvial pockets or basins. Again, because the distribution of well and spring data is inadequate to define what is apparently a complex groundwater system, no attempt was made to contour water levels in the White Hills. The one exception to this statement involves the tributary valley to Hualapai Valley south of Table Mountain Plateau, where water levels have been contoured.

RECENT BLM WELL FAILURES

Five dry holes were drilled by the U.S. Bureau of Land Management (BLM) between the years 1977 and 1980. The site numbers and well names for these holes are identified in Table 3. Also included in Table 3 are brief descriptions of the location of each well with respect to geologic features, as well as specific lithologic and hydrologic data provided by the driller's log for each hole. The well locations are illustrated on the hydrogeologic map (Plate 3).

Our interpretation of why each of these wells was dry follows. In summary, all five wells fall into a consistent pattern; each well was drilled mostly in crystalline bedrock in or near the mountains, whereas the major groundwater-bearing unit in the study area is the alluvium beneath the valleys. With the term crystalline bedrock, we include younger volcanics, older volcanics, and Precambrian igneous and metamorphic rocks. Four of the five wells do penetrate 10 to 30 feet of soil or alluvium at the top, but this porous material in each case is dry because it lies above the water table.

Because groundwater in the crystalline bedrock occurs only in fractured zones, weathered zones and tuff beds, the groundwater is highly localized. That is, water does not flow uniformly through the system, but rather, its occurrence is controlled by fracture alignment and density. Thus, where two wells are drilled into bedrock near each other, one could encounter water while the other is dry. It is therefore not surprising that many wells drilled into the bedrock do not encounter water.

On the basis of the available data, we conclude that each of the five dry BLM wells is dry because it is unfavorably located with respect to a complex groundwater system in the bedrock. We point out that the failure of one particular well, Tennessee Wash Well, number (23-18)20aaa, is explained specifically in the discussion above of cross-section BB' in

Table 3: DATA FOR RECENT BLM WELL FAILURES

Well Name and Site Number	Location with Respect to Geologic Features	Data from Driller's Log
Tennessee Wash Well (23-18)20aaa	In northern Sacramento Valley; upthrown side of postulated range-front fault	0- 20 feet Top soil 20-375 feet Granite 375 feet Bottom of hole No water encountered.
Sugarloaf Well (23-19)16cc	In younger volcanics on eastern flank of Black Mountains	0- 12 feet Top soil 12-300 feet Hard rock 300 feet Bottom of hole No water encountered.
Mockingbird Well (26-21)15ada	In Precambrian bedrock on eastern flank of Black Mountains	0-425 feet Granite and schist 425 feet Bottom of hole Water encountered at 165 and 210 feet, but will not hold a static level.
Little Horse Well (27-19)20dcd	On the edge of one of the small alluvial basins in the White Hills	0- 30 feet Loose sand and gravel 30-200 feet Volcanic rock and granite, very fractured 200 feet Bottom of hole Very dry; no static water after 12 hours.
White Hills Well (28-19)1bb	In a granite bedrock outcrop portion of the White Hills	0- 10 feet Top soil and loose rock 10-300 feet Bedrock 300 feet Bottom of hole Dry

the northern Sacramento Valley. We have no specific evidence that drilling methods were responsible for any of the well failures.

The fact that the five dry BLM wells were drilled mostly in bedrock is now readily determined by reviewing the driller's log for each hole. However, before each well was drilled, it may not have been obvious that the well was likely to encounter shallow bedrock. Nevertheless, as a result of this study, data now are available for scientifically predicting favorable locations for future water wells. The combination of the geologic and hydrologic data shown on Plates 1 and 3, the well and spring data compiled in Appendix A, and the detailed hydrogeologic analysis presented in this report provides a sound scientific basis for future water resources planning and development.

Chapter VI

GROUNDWATER QUALITY

This chapter contains a discussion of the methodology of water sample collection and testing by Geo/Resouce Consultants (GRC) in the field, the water quality testing in the laboratory, and finally, our analysis of groundwater quality in the Detrital and Hualapai basins based on the available data. Although most of the data used in our analysis was gathered during the present investigation, data from two other sources (Remick, 1981; Gillespie, Bentley and Kam, 1966) were also used. All of these water quality data appear in the water quality data tables in Appendix B.

FIELD METHODOLOGY

Sixty-three water samples were collected during the field investigation and analyzed. Collection points were chosen to represent a broad geographic distribution of sites. The coverage was limited in some areas because of access difficulties. Generally, no more than one sample was collected from a single section of land.

Water samples from wells with pumps were collected as close to the wellhead as possible. Wells were pumped for at least ten minutes before a sample was collected, so the water would be fresh from the aquifer. If the water had been stored in pipes or tanks, a note was made on the well schedule form. Wells without pumps were sampled using a bottom-filling type polyvinyl chloride plastic water sampling cylinder with a slot screen at the intake and a ball check. The cylinder was lowered to a position several feet (to several tens of feet) below the water surface in the well to retrieve the sample. Water from springs was collected directly into sample bottles at the source.

Temperature, pH, and specific conductance of water samples were determined and recorded immediately upon collection. Each sample was split into several fractions. The fractions were prepared and stored according to specified procedures so that accurate determinations could be made in the laboratory. Samples were sent (airmail) approximately once per week to the U.S. Geological Survey Water Resources Division Central Water Laboratory in Arvada, Colorado.

LABORATORY TESTING

All samples were tested in the laboratory for pH and specific conductance, as well as to determine concentrations of major ions including calcium, magnesium, sodium, potassium, silica, iron, boron, chloride, sulfate, fluoride, hardness as calcium carbonate, non-carbonate hardness, and residue on evaporation at 180 degrees Centigrade. Selected samples were also tested for concentrations of nitrogen (as nitrate/ nitrite), phosphorus, orthophosphate, and heavy metals including aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, gallium, germanium, lead, lithium, manganese, molybdenum, nickel, silver, strontium, tin, titanium, vanadium, zinc, and zirconium. Many of the determinations of heavy metals concentrations are semi-quantitative; that is, only concentrations above a certain limit are reported. This analysis technique is typical for reconnaissance evaluations such as this study. Concentrations are recorded in milligrams per liter (mg/l) and micrograms per liter (ug/l). A mass-balance calculation was performed to check the results for each sample tested.

ANALYSIS OF WATER QUALITY DATA

Detrital and Northern Sacramento Valleys

Water quality in the Detrital Valley area is generally good. Ionic concentrations are moderate, with total dissolved

solids (residues upon evaporation) ranging from approximately 225 to 750 mg/l. For comparison, the maximum recommended limit for total dissolved solids in domestic water supplies, as established by the U.S. Environmental Protection Agency (EPA), is 500 mg/l (U.S. Environmental Protection Agency, 1979). The water in Detrital Valley may be characterized as hard to very hard. EPA criteria for hardness indicate that a concentration of 0 to 75 mg/l hardness as calcium carbonate represents soft water, 75 to 150 mg/l represents moderately hard water, 150 to 300 mg/l represents hard water, and over 300 mg/l represents very hard water (U.S. Environmental Protection Agency, 1976, p. 75).

Both major ion and heavy metal ion concentrations tend to be higher in samples collected in and near the mountains bordering Detrital and Sacramento Valleys than in samples from beneath the central parts of the valleys. All sites in the Detrital basin that have ionic concentrations exceeding the EPA recommended limits for domestic water use are listed in Table 4. The table includes the measured excessive concentrations found at each site, as well as the EPA standard for each ion in question. All but one site listed in Table 4 are located in or near the mountains bordering Detrital Valley. In summary, samples from the eastern Black Mountains contain concentrations above EPA recommended limits of arsenic, lead, manganese, fluoride and sulfate. Three samples from the White Hills exhibit fluoride concentrations above EPA limits. In addition, local residents report high concentrations of arsenic in the groundwater of the northern White Hills near Senator Mountain and Golden Rule Peak. Arsenic concentrations in the water from this area were not measured during this investigation.

All but one groundwater sample from beneath the central part of Detrital Valley were of good quality. The one exception was collected from well (29-21)35ccc in northern Detrital

Table 4: SITES IN THE DETRITAL BASIN WITH IONIC CONCENTRATIONS EXCEEDING EPA RECOMMENDED LIMITS FOR DOMESTIC WATER SUPPLIES

	Ion	Site Number	Ion Concentration at Site	EPA Maximum Recommended Limit*
EASTERN BLACK MOUNTAINS	Arsenic:	(25-21)27aba	54 ug/l	50 ug/l
		(27-21)29cba	2000 ug/l	
	Lead:	(27-21)29cba	50 ug/l	50 ug/l
	Manganese:	(25-21)23ccc	100 ug/l	50 ug/l
	Fluoride:	(25-21)27aba	3.0 mg/l	1.6 mg/l**
		(25-21)35dab	2.4 mg/l	
		(28-21)20aac	1.8 mg/l	
	Sulfate	(27-21)29cba	2400 mg/l	250 mg/l
WHITE HILLS	Fluoride:	(27-19) 7cbd	3.9 mg/l	1.6 mg/l**
		(27-19)12acc	2.2 mg/l	
		(27-20)14adc	1.9 mg/l	
CENTRAL DETRITAL VALLEY	Sulfate:	(29-21)35ccc	290 mg/l	250 mg/l

ug/l = micrograms per liter = 10^{-6} grams per liter
mg/l = milligrams per liter = 10^{-3} grams per liter

* Sources for EPA recommended limits:
Fluoride: U.S. Environmental Protection Agency, 1975, p. 5
Sulfate: U.S. Environmental Protection Aency, 1979, p. 42198
Other Ions: U.S. Environmental Protection Agency, 1976

** Fluoride criterion based on average maximum daily temperature of 70.7 to 79.2 degrees Fahrenheit

Valley. It contained a high concentration of sulfate, probably supplied by dissolution of nearby buried evaporite stata. It should be noted that slightly elevated ionic concentrations are to be expected in Detrital Valley groundwater, because a large portion of the reservoir is mildly geothermal. Water temperatures range from approximately 20 to greater than 30 degrees Centigrade.

Table 5 contains a list of all the sites in the northern Sacramento Valley area which have ionic concentrations exceeding the EPA recommended limits for domestic water use. The table also lists the excessive concentrations found at each site and the relevant EPA standards. All of the sites with excessive ionic concentrations occur in or very near the western edge of the Cerbat Mountains. In summary, concentrations above EPA recommended limits of lead, manganese, zinc, iron, sulfate, chloride and fluoride were found. The elevated levels of heavy metals are probably associated with mineralized zones in the western Cerbat Mountains where mining activities have occurred.

Hualapai Valley

With a few exceptions, water quality in the Hualapai Valley area is also good. Total dissolved solids (residues upon evaporation) range from approximately 350 to 1250 mg/l, somewhat higher than those found in Detrital Valley water. The water is hard to very hard. EPA criteria for total dissolved solids and hardness in domestic water supplies are discussed above in the section on Detrital Valley.

As was the case with Detrital and northern Sacramento Valleys, higher ionic concentrations were found in groundwater in and near the mountains bordering Hualapai Valley than in groundwater beneath the central parts of the valley. Table 6 contains a list of sites in the Hualapai basin with ionic concentrations exceeding EPA recommended limits for domestic

Table 5: SITES IN THE NORTHERN SACRAMENTO VALLEY AREA WITH IONIC CONCENTRATIONS EXCEEDING EPA RECOMMENDED LIMITS FOR DOMESTIC WATER SUPPLIES

Ion	Site Number	Ion Concentration at Site	EPA Maximum Recommended Limit*
Lead:	(22-17) 7cdd2	60 ug/l	50 ug/l
	(23-18)35dcc	50 ug/l	
Manganese:	(22-17) 7cdd1	140 ug/l	50 ug/l
	(23-18) 6aad	1000 ug/l	
	(23-18)15baa	700 ug/l	
	(23-18)35dcc	150 ug/l	
Zinc:	(23-18) 6aad	7000 ug/l	5000 ug/l
Iron:	(22-17) 7cdd1	1100 ug/l	300 ug/l
	(23-18)35dcc	11,000 ug/l	
Sulfate:	(22-17) 7cdd1	480 mg/l	250 mg/l
	(22-17) 7cdd2	680 mg/l	
	(23-18) 6aad	900 mg/l	
	(23-18)15baa	1200 mg/l	
	(23-18)35dcc	1600 mg/l	
	(22-18)12caa	295 mg/l	
	(23-18) 3adb	475 mg/l	
	(23-18) 3cbb	460 mg/l	
Chloride:	(23-18) 6aad	1300 mg/l	250 mg/l
	(23-18)15baa	330 mg/l	
	(23-18) 3cbb	264 mg/l	
Fluoride:	(22-17) 7cdd2	2.3 mg/l	1.6 mg/l**
	(23-18) 3adb	2.2 mg/l	
	(23-18) 3cbb	1.7 mg/l	

ug/l = micrograms per liter = 10^{-6} grams per liter
mg/l = milligrams per liter = 10^{-3} grams per liter

* Sources for EPA recommended limits:
Fluoride: U.S. Environmental Protection Agency, 1975, p. 5
Sulfate and Chloride: U.S. Environmental Protection Agency, 1979, p. 42198
Other Ions: U.S. Environmental Protection Agency, 1976

** Fluoride criterion based on average maximum daily temperature of 70.7 to 79.2 degrees Fahrenheit

Table 6: <u>SITES IN THE HUALAPAI BASIN WITH IONIC CONCENTRATIONS EXCEEDING EXCEEDING EPA RECOMMENDED LIMITS FOR DOMESTIC WATER SUPPLIES</u>

	Ion	Site Number	Ion Concentration at Site	EPA Maximum Recommended Limit*
EASTERN CERBAT MOUNTAINS	Sulfate:	(23-17)35bdb	557 mg/l	250 mg/l
GRAND WASH CLIFFS	Sulfate:	(25-14)15bab	310 mg/l	250 mg/l
		(26-14)30ccb	390 mg/l	
		(26-15)23dac	430 mg/l (GRC)	
		(26-15)23dac	259 mg/l (Remick)	
		(27-15)27bca	420 mg/l	
		(28-17)24bcc	490 mg/l	
	Chloride:	(25-14)15bab	260 mg/l	250 mg/l
	Fluoride:	(25-14)15bab	2.9 mg/l	1.6 mg/l**
		(26-14)30ccb	5.7 mg/l	
		(26-15)23dac	2.7 mg/l	
		(27-15)27bca	4.1 mg/l	
		(28-17)24bcc	6.3 mg/l	
		(29-17)36dda	3.0 mg/l	
WESTERN PEACOCK MOUNTAINS	Iron:	(23-15)13ccb	2,600 ug/l	300 ug/l
	Fluoride:	(23-15)13ccb	2.3 mg/l	1.6 mg/l**
EASTERN PEACOCK MOUNTAINS	Iron:	(23-13)19cbb	900 ug/l	300 ug/l
COTTONWOOD MOUNTAINS	Chloride:	(22-13)13aad	330 mg/l	250 mg/l
CENTRAL HUALAPAI VALLEY	Chloride:	(28-17)31ccc	528 mg/l	250 mg/l
	Fluoride:	(23-15) 4ddd	5.6 mg/l	1.6 mg/l**
		(23-15) 8ddd	1.7 mg/l	

ug/l = micrograms per liter = 10^{-6} grams per liter
mg/l = milligrams per liter = 10^{-3} grams per liter

* Sources for EPA recommended limits:
Fluoride: U.S. Environmental Protection Agency, 1975, p. 5
Sulfate and Chloride: U.S. Environmental Protection Agency, 1979, p. 42198
Other Ions: U.S. Environmental Protection Agency, 1976

** Fluoride criterion based on average maximum daily temperature of 70.7 to 79.2 degrees Fahrenheit.

water use. The table also lists the excessive concentrations found at each site and the relevant EPA standards.

For sites in and near the mountains, the distribution of ionic concentrations above EPA limits may be summarized as follows. In the eastern Cerbat Mountains, one site shows a concentration of sulfate above the EPA recommended limit. Several samples from the Grand Wash Cliffs contained elevated levels of sulfate, chloride and fluoride. One site in the western Peacock Mountains exhibited excessive concentrations of both iron and fluoride. Just east of the Peacock Mountains, near Hackberry, one sample contained a high level of iron. In the Cottonwood Mountains, one site with a high concentration of chloride was found.

Although most water samples from the central parts of Hualapai Valley were of good quality, ionic concentrations above EPA limits were measured in three samples. One site north of Red Lake has an excessive concentration of chloride, and two sites east of Long Mountain have elevated levels of fluoride. In addition, excessive concentrations of chromium are known to occur in some wells drilled in the alluvium northeast of Kingman (Devlin, 1982). The EPA maximum recommended limit for chromium in domestic water is 50 micrograms per liter (U.S. Environmental Protection Agency, 1976, p. 37). However, the elevated chromium levels are apparently somewhat limited geographically, because no elevated chromium concentrations were detected in any samples collected by GRC.

<u>Explanation of Results</u>

The following conditions were found to exist in both the Detrital and Hualapai basins. The major cations and anions exhibit variations in concentration over approximately one order of magnitude, with most values grouped near the ends of the range. In general, the sites exhibiting higher ionic concentrations occur near the perimeter of the alluvial

deposits; that is, in and adjacent to the mountains bordering the valleys. The sites exhibiting lower ionic concentrations are generally out in the central areas of the alluvial valleys. Several factors may contribute to the differences in water quality between wells in central alluvium and wells near the perimeter of the valleys. These factors are discussed in the following paragraphs.

Direct recharge to the alluvium occurs when there is sufficient rainfall to cause flow in the ephemeral streams leading from the surrounding mountains into the valleys. Water percolates from the stream channels to the underlying aquifer, traveling only a short distance underground, and therefore having little opportunity to dissolve and transport minerals. Thus, it arrives at the water table with relatively low levels of metals and other dissolved solids. Water in wells in the central areas of the valleys has this type of direct recharge as its main source; hence the low levels of most constituents.

The alluvium near the perimeter of the valleys also receives high quality water from direct precipitation recharge. However, significant quantities of water may also be flowing into the alluvium through fractured bedrock aquifers from the surrounding mountains. These waters are expected to have elevated levels of dissolved metals and other ions because they have traveled considerable distances underground from the recharge areas, probably through weathered, mineralized zones. Mining activities in the area indicate the presence of mineralized rock which could contribute dissolved solids to the groundwater. Elevated levels of metals in groundwater are fairly typical in active and potential mining areas, where weathering exposes metal ores to oxidation and to contact with percolating groundwater.

Other factors that may contribute to the difference between water quality in wells in the central parts of the basins and in wells near the perimeter include (1) greater

thickness of alluvium near the center, (2) density stratification within the alluvium, and (3) clay lenses within the alluvium. Wells tapping central parts of the alluvium penetrate only a fraction of the total depth, whereas those near the perimeter may penetrate the entire alluvium thickness and even into bedrock. Water quality in the upper alluvium may be better than in lower zones of the aquifer for two reasons: (1) density stratification, and (2) percolation of relatively good quality recharge into this zone. Wells tapping only the upper zone of the alluvium would tend to skim off this high quality water, as they do not penetrate into deeper zones where more mineralized waters are present. In contrast, wells near the perimeter of the alluvium intercept a mixture of water from the entire thickness of the alluvium that also includes water upwelling from the surrounding bedrock.

Clay lenses within the alluvium have considerable potential for immobilizing dissolved minerals, particularly metals that are mobile at low pH values. Water entering the alluvium from the surrounding bedrock aquifer may improve in quality prior to reaching wells in the central part of the alluvium, as a result of contact with these clay lenses.

In summary, water quality in Detrital and Hualapai Valleys is of moderate to good quality, exhibiting an order-of -magnitude range of dissolved solids content. These dissolved solids are indicative of contact with mineralized rock. The range of values appears to be a function of well location, with higher dissolved solids content associated with wells near the perimeter of the alluvium. Possible reasons for this notable difference in water quality with location include (1) distance the water travels through weathered bedrock between the recharge area and the discharge point at the well, (2) density stratification within the groundwater, which keeps the more mineralized water below the level of most wells in the central alluvium, (3) availability of fresh recharge waters to the

upper alluvium, and (4) immobilization of dissolved minerals by clay lenses within the alluvium.

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APPENDIX A

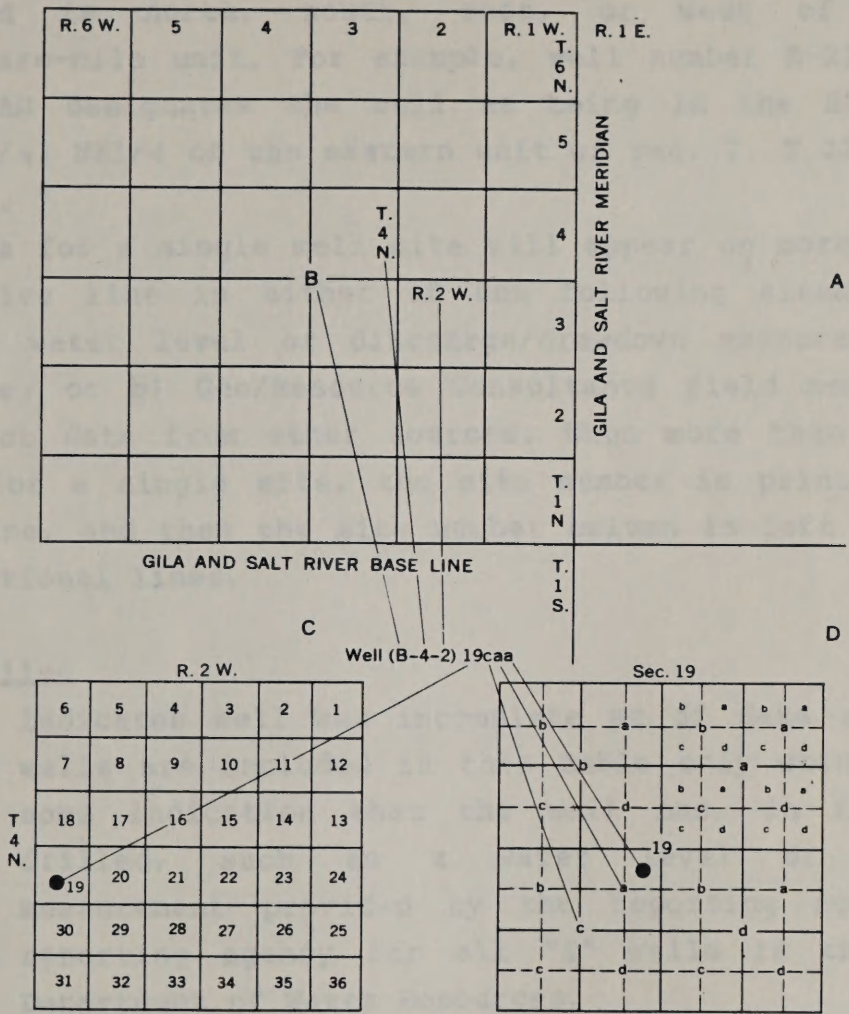
APPENDIX A
Well and Spring Data Tables

EXPLANATION

Site Number

All site entries are listed in order of township, range, section and so forth. The well data are tabulated separately from the spring data. An explanation from the U.S. Geological Survey of the site numbering system is given below.

> "The local number or well number is the location of a well to the nearest 10 acres in an abbreviated form. The well numbers used by the geological survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River Meridian and base line, which divide the state into four quadrants. These quadrants are designated counterclockwise by the letters A, B, C, and D. All land north and east of the point of origin is in the A quadrant, that north and west in the B quadrant, that south and west in the C quadrant, and that south and east in the D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The letters A, B, C, and D after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counter-clockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three letters are shown in the well number. In the example shown, well number B-4-2 19CAA designates the well as being in the NE1/4 NE1/4 SW1 /4 sec. 19, T. 4N, R. 2W. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.



"Oversize sections occur in a few areas in the state. Where a section is more than a mile in any dimension, the excess area is considered a part of that section and has the same section number. The oversized section is divided so that a square mile unit is adjacent to a normal section within the same township; the rest of the section is considered a separate unit in which appropriate N, S, E, or W

letters are assigned, depending on whether the excess land is north, south, east, or west of the square-mile unit. For example, well number B-22-16E 07AAD designates the well as being in the SE1/4, NE1/4, NE1/4 of the eastern unit of sec. 7, T 22N, R 16W. "

Data for a single well site will appear on more than one consecutive line in either of the following situations: a) multiple water level or discharge/drawdown measurements are available; or b) Geo/Resource Consultants field measurements contradict data from other sources. When more than one line occurs for a single site, the site number is printed on the first line, and then the site number column is left blank for the additional lines.

Date Drilled

I Indicates well was incomplete as of date shown. "I" wells are included in this table only when there is some indication that the well has, in fact, been drilled, such as a water level or discharge measurement provided by the reporting agency. The reporting agency for all "I" wells is the Arizona Department of Water Resources.

Well Depth

H Horizontal well

Water Use

C Commercial
H Domestic
I Irrigation
N Industrial
P Public Supply
S Stock

U Unused
W Wildlife
Z Other

Water Level

The letter after the water level column indicates the status of the site at the time of measurement. If no letter appears, the measured water level represents the true static level at the site in feet below land surface.

Site Status

D Dry
DD Destroyed
F Flowing
O Obstruction, could not measure
P Pumping
R Recently pumped
S Nearby pumping
X Water level affected by stage in nearby surface water site
Z Other
? Water-level measurement was reported, and status at time of measurement is unknown.

Date of GRC Observation

Entry indicates the date the site was field-checked by Geo/Resource Consultants. The letter after the date indicates the status of the site at the time of the field-check. Site status symbols are explained above.

Water Quality Tested by GRC

A "Yes" or "No" entry indicates whether or not Geo/Resource Consultants collected a water sample from the site for laboratory analysis. A blank entry indicates that Geo/Resource Consultants did not field check the site.

Producing Formation

The entry indicates either the producing formation of the well or spring or, in the case of a dry hole, the formation in which the hole bottomed out. The symbols used correspond to geologic units which are described in more detail in the legend to the Geologic Map. The symbols are briefly described below.

Alluv	Includes younger alluvium (Qal), intermediate alluvium (QTs) and older alluvium (Ts)
Tv	Younger volcanics
Br	Bedrock, including older volcanics and Precambriam igneous and metamorphic rocks
DCs	Paleozoic sedimentary rocks

The entries in the producing formation column for wells are based upon driller's logs, where available. Otherwise the entries are based upon interpretations from available well data including well location, depth, discharge rate and water level in relation to wells of known producing formation. The sources indicated in the data sources column do not necessarily apply to the producing formation.

The entries in the producing formation column for springs are based upon direct field observations.

Data Sources

USGS	U.S. Geological Survey computerized data base for Arizona well data, obtained from the U.S.G.S., Phoenix Subdistrict office, Phoenix, Arizona.
ADWR	Arizona Department of Water Resources computerized data base for Arizona well data, obtained from the Arizona State Lands Department, Division of Water Resourcs, Phoenix, Arizona.

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A question mark following the "R" indicates that Remick visited one of two or three adjacent wells, but the exact well visited is not known.

ABM Arizona Bureau of Mines: Pierce, H. Wesley, and James R. Scurlock, 1972, "Arizona Well Information", Ariz. Bureau of Mines Bull. 185. (NOTE: The new name for the Arizona Bureau of Mines is now the Arizona Bureau of Geology and Mineral Technology).

GRC Geo/Resource Consultants field investigation: The "GRC" data source designation corresponds exactly with all the sites for which BLM well schedule forms were filled out by Geo/Resource Consultants during the field investigation. "GRC" as a data source includes data measured directly in the field, as well as data reported by drillers, well owners or other local individuals. The exact source of reported data is specified (i.e., "DR", "OWN", "OTH"), in addition to "GRC", only when water level or discharge/drawdown measurements are involved.

DR Driller's Report

OWN Well owner

OTH Reporting source for water level or discharge/ drawdown other than the driller or well owner. Other reporting sources include the water user, a consultant, or some other local individual.

Table A-1: SPRING DATA--DETRITAL AND HUALAPAI BASINS

Site No.	Water Use	Altitude (feet)	Discharge (gpm)	Date Measured (by GRC)	Water Quality Tested	Producing Formation	Owner or User
B-21-17 02CCB	W	3765	22.0	5/7/82	Yes	Tv	--
B-23-15 13CCB	S	3833	0.4	4/17/82	Yes	--	--
B-24-14 24CAA	S	3915	0.0	4/15/82	No	Br (granite gneiss)	BLM
B-24-18 33BBA	H&S	4242	<1.0	3/16/82	No	Br	--
B-25-21 02CCB	S	4271	5.5	4/3/82	Yes	Br (granite gneiss)	BLM
B-25-21 23CCC	S	4257	<0.1	3/27/82	Yes	Br (granite gneiss)	--
B-26-18 31BDB	P	3750	2.1	5/4/82	Yes	Br (granite gneiss)	Lake Mohave Ranchos Water Co.
B-26-19 20ACD	S	3288	2.3	4/4/82	Yes	Br (vesicular andesite)	BLM
B-26-21 36DDD	S	3364	<0.1	4/3/82	No	--	BLM
B-27-15 15AAC	S	4555	0.5	4/16/82	Yes	DCs (quartz vein in bedded limestone)	BLM
B-27-15 27BCA	W	3844	0.08	4/16/82	Yes	Br (granite gneiss)	BLM
B-27-19 11ADB	S	4275	0.2	3/20/82	Yes	Br (Older Volcanics/ granite gneiss contact)	--
B-28-17 24BCC	S	4140	0.3	4/22/82	Yes	Br	Carson Water Co.
B-30-22 13ADA	S&W	3215	5.5	3/19/82	No	Br (schist/granite gneiss contact)	BLM

Table A-2: WELL DATA--DETRITAL AND HUALAPAI BASINS

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-20-15 04BD	--	165	--	S	5600	--	--	--
B-20-15 05BBC	--	785	6	H	4940	720.00	1964	--
B-20-15 06AAC	--	--	--	H	4950	--	--	--
B-20-15 06CCB	--	--	6	H	5215	15.50	03/18/80	--
B-20-15 20AAB	--	90	--	U	4500	--	--	--
B-20-15 20CCA	-- 1976	47	8	H	--	27	--	--
B-20-16 02ADC	--	140	--	S	4800	70.00	1964	--
B-20-16 06C	1952	125	6	S	3600	93.74	05/14/52	--
B-20-16 06DAC	--	150	--	S	3780	--	--	--
B-20-16 10AAC	--	90	--	H	4540	60.00	1963	--
B-20-16 12ABB	12/28/1977	90	6	H	4940	60.00	12/28/77	--
B-20-16 12ABC	11/25/1977	140	6	--	5040	32.07	02/26/79	--
B-20-16 12ABD	12/23/1977	125	6	H	5020	60.00	12/23/77	--
B-20-16 12ACA	1977	140	6	H	--	50	--	--
B-20-16 12ACB	1978	125	6	H	--	40.00	--	--
B-20-16 12ACC	1977	145	6	H	--	50	--	--
B-21-14 29BBC	04/01/1980	595	--	U	4260	-- D	04/01/80	--
B-21-14 29CCC	--	354	6	U	4340	-- D	07/15/69	--
B-21-14 31CCC1	1951	350	6	U	4590	150.95	07/15/69	--
B-21-14 31CCC2	--	250	6	U	4590	152.75	07/15/69	--
B-21-14 31CCC3	--	300	8	C	4585	51.90	05/21/80	--
B-21-14 31CCC4	04/30/1980	575	--	--	--	D	04/30/80	--
B-21-14 32BBA	1981	490	--	S	--	-- D	--	--
B-21-15 19DAB	11/01/1960	152	6	S	4230	92.70	03/ /80	--
B-21-15 20CAB	--	--	8	S	4255	86.40	03/05/80	--
B-21-15 20CAD	--	--	8	S	4280	81.00	03/05/80	--
B-21-15 26BDD	--	48	--	S	4440	14.53	04/07/52	--
B-21-15 26CAD1	--	--	--	U	4482	11.50	03/05/80	--
B-21-15 26CAD2	08/31/1970	220	6.63	S	4482	36.00	03/05/80	--
B-21-15 28BCA1	--	200	--	S	4400	110.00	--	--
B-21-15 28BCA2	--	450	--	S	4400	110.00	1964	--
B-21-15 28BDB	--	212	--	U	4450	200.00	1964	--
B-21-15 29AAA	--	160	--	S	4400	80.00	1964	--
B-21-15 33BBB	1963	700	--	H	4620	75.00	1964	--
B-21-15 36CD	--	--	--	S	4800	--	--	--
B-21-16 06CBB	03/ /1977	480	12	--	--	310	03/ /77	--
B-21-16 14CDD	--	690	8	U	3780	484.90	03/11/80	--
B-21-16 17DCA	08/01/1979	495	--	--	--	-- D	08/01/79	--
B-21-16 20CDB	1965	474	--	U	3655	388.20	03/11/80	--
B-21-16 23DBC	--	30	--	U	3935	16.80	03/11/80	--

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-21-16 24BDA	--	85	8	S	3980	71.30	03/11/80	--
B-21-16 24CAA1	--	86	8	U	4042	24.50	03/11/80	--
B-21-16 24CAA2	--	--	--	U	4000	--	03/11/80	--
B-21-16 24CDA	--	--	6	U	4190	26.00	03/11/80	--
B-21-16 24DCC	--	--	--	U	4227	16.20	03/11/80	--
B-21-16 29BBD	1954	500	--	S	3600	290.00	1964	--
B-21-16 35AD	--	233	--	S	4500	212.00	1964	--
B-21-16 35CBC1	--	154	--	S	4300	60.00	1964	--
B-21-16 35CBC2	--	90	--	S	4300	--	--	--
B-21-17 01BAA	04/20/1977	300	6	--	--	110	04/20/77	--
B-21-17 01CAB	--	503	--	P	3400	115.00	12/ /63	--
B-21-17 01CCB	--	--	--	C	3560	154.60	03/11/80	--
B-21-17 01DBC	06/28/1977	350	7	--	--	110	06/28/77	--
B-21-17 02CCD	--	60	14	U	3760	2.60	07/20/78	05/07/1982 DD
B-21-17 03CDA1	--	385	--	U	3930	51.20	08/13/43	--
B-21-17 03CDA2	--	175	--	U	3924.7	45.20	05/20/43	--
B-21-17 03CDA3	1943	187	--	U	3923.2	47.48	07/18/43	--
B-21-17 03CDA4	1944	129	14	U	3906.5	79.95	10/10/79	--
	--	140	16	--	--	58.15	05/07/82	05/07/82
B-21-17 03DDB	1943	750	16	U	3833.9	30.96	12/10/51	--
B-21-17 10DDC	06/26/1978	90	6	H	3670	45.00	06/26/78	--
	--	--	--	--	--	42.9	04/ /82	05/07/82 O
B-21-17 11CCA	--	140	--	S	3620	50.00	04/27/78	--
B-21-17 11CCC	1979	100	4	--	--	50	1979	--
B-21-17 11DAA	1969	990	10	H	3625	--	--	--
B-21-17 13DBB	1966	518	--	H	3530	303.00	01/ /66	--
B-21-17 14AAC	07/07/1972	150	6	--	--	120	07/07/72	--
B-21-17 14BA	--	--	--	H	--	3.95	12/10/51	--
B-21-17 14BAB	01/23/1980	160	6	--	--	10	01/23/80	--
B-21-17 14BCC	--	--	--	--	3522	14.00	04/27/78	--
	03/01/1978	100	6	--	--	55 ?	03/01/78	--
B-21-17 14BD	1942	300	10	U	--	-- D	--	--
B-21-17 14CCB	--	--	--	H	3508	8.00	04/27/78	--
B-21-17 15BCC	--	250	--	--	3760	--	--	--
B-21-17 19BAB	--	600	--	U	3070	105.00	1964	--
B-21-17 23AAC	1957	250	--	H	3387	180.00	1957	--
B-21-17 23ABC1	--	260	--	H	3384	190.00	12/ /64	--
B-21-17 23ABC2	--	360	--	H	3386	225.00	03/ /64	--

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN)	AND DATE MEASURED	DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	0.78	--	--	--	USGS, R	--	B-21-16 24BDA
--	0.78	--	--	--	USGS	--	B-21-16 24CAA1
--	--	--	--	--	USGS	--	B-21-16 24CAA2
--	--	--	--	--	USGS, R	--	B-21-16 24CDA
--	--	--	--	--	USGS	--	B-21-16 24DCC
--	25	--	--	--	USGS	--	B-21-16 29BBD
--	0.00	--	--	--	USGS	--	B-21-16 35AD
--	--	--	--	--	USGS	--	B-21-16 35CBC1
--	--	--	--	--	USGS	--	B-21-16 35CBC2
--	--	--	--	--	DR	Short	B-21-17 01BAA
--	300	--	--	Alluv	USGS	--	B-21-17 01CAB
--	--	--	--	--	USGS, R	--	B-21-17 01CCB
--	--	--	--	Alluv	DR	Larson	B-21-17 01DBC
NO	--	--	--	Tv	USGS,GRC	--	B-21-17 02CCD
--	--	--	--	--	USGS	--	B-21-17 03CDA1
--	--	--	--	--	USGS	--	B-21-17 03CDA2
--	183	--	--	--	USGS	--	B-21-17 03CDA3
--	--	--	--	--	USGS	--	B-21-17 03CDA4
NO	--	--	--	Tv	GRC	--	
--	--	--	--	--	USGS	--	B-21-17 03DDB
--	--	--	--	--	USGS	--	B-21-17 10DDC
YES	30	05/07/82	--	Tv	GRC, OWN	Lawrence	
--	--	--	--	Tv	USGS	--	B-21-17 11CCA
--	20	1979	--	Tv	DR	McCall	B-21-17 11CCC
--	--	--	--	--	USGS	--	B-21-17 11DAA
--	3	--	--	--	USGS	--	B-21-17 13DBB
--	--	--	--	--	DR	Leonard	B-21-17 14AAC
--	--	--	--	--	USGS	--	B-21-17 14BA
--	--	--	--	Tv	DR	Bond	B-21-17 14BAB
--	--	--	--	Tv	USGS	--	B-21-17 14BCC
--	--	--	--	--	DR	Ware	
--	--	--	--	--	USGS	--	B-21-17 14BD
--	--	--	--	Tv	USGS	--	B-21-17 14CCB
--	300	--	--	--	USGS	--	B-21-17 15BCC
--	0.5	--	--	--	USGS	--	B-21-17 19BAB
--	10	--	--	--	USGS	--	B-21-17 23AAC
--	18	--	--	--	USGS	--	B-21-17 23ABC1
--	10	--	--	--	USGS	--	B-21-17 23ABC2

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-21-17 23ADB1	--	161	--	U	3400	145.88	08/14/44	--
B-21-17 23ADB2	193??	181	6	H	3400	160.80	12/10/64	--
B-21-17 23BBB	01/23/1977	300	8	H	3455	240.00	01/23/77	--
	--	--	10	--	--	--	--	05/07/82 P
B-21-17 23BCD	1956	355	8	--	3391	120.00	1956	--
B-21-17 24BCA	12/28/1978	300	6	H	3400	180.60	02/12/79	--
	--	--	--	--	--	200	12/28/78	--
B-21-17 24CAD	--	--	--	--	3355	--	--	--
B-21-17 24CBB	--	165	--	U	3350	109.08	08/14/44	--
B-21-17 24CBC	1920	--	--	P	3330	180.00	05/ /65	--
B-21-17 24CBD	--	--	--	--	3345	--	--	--
B-21-17 24CCA	--	135	--	H	3328	97.00	12/ /64	--
B-21-17 24CCB	--	160	--	H	3338	97.00	11/15/64	--
B-21-17 24CDA	1917	178	12	U	3340	122.80	10/01/64	--
B-21-17 24CDB	1912	232	12	P	3335	92.00	06/21/32	--
B-21-17 24CDD1	1920	--	--	P	3332	50.00	1920	--
B-21-17 24CDD2	--	120	--	--	3335	101.46	08/14/44	--
B-21-17 24DCA	1948	357	8	C	3397	120.00	1948	--
B-21-17 24DCD	--	200	--	H	3360	112.95	08/14/44	--
B-21-17 24DDC	--	--	--	C	3380	--	--	--
B-21-17 25AAA	1963	460	8	H	3385	180.00	03/ /63	--
B-21-17 34ACA	--	100	--	H	3090	65.00	05/03/78	--
B-21-17 34B	--	60	--	S	3100	54.10	02/18/52	--
B-21-17 34BBB	--	168	--	H	3150	153.00	--	--
B-21-17 34D	1909	--	48	H	3080	59.66	02/15/52	--
B-21-17 34DAD	07/14/1977	107	10	--	3060	65.00	07/14/77	--
B-21-17 34DCA	06/01/1960	100	8	--	3040	64.53	03/02/79	--
B-21-17 34DDB	1949	80	6	U	3050	60.10	02/15/52	--
B-21-17 34DDC	1949	80	6	H	3040	63.04	02/15/52	--
B-21-17 35BBC1	10/17/1977	175	8	U	--	75	10/17/77	--
B-21-17 35BBC2	10/14/1977	175	8	I	--	75	10/14/77	--
B-21-17 35BBC3	09/30/1977	175	8	I	--	75	09/30/77	--
B-21-17 35BBC4	11/23/1977	175	6	H	--	60	11/23/77	--
B-21-17 35BD	1913	59	24	N	3150	49.13	02/23/52	--
B-21-17 35C	--	84	--	H	3086	66.75	02/15/52	--
B-21-17 35CAA	1947	106	12	H	3105	72.90	02/20/52	--
B-21-17 35CBD	--	96	--	H	3080	26.00	11/ /61	--

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	--	--	--	--	USGS	--	B-21-17 23ADB1
--	12	--	--	--	USGS	--	B-21-17 23ADB2
--	--	--	--	--	USGS	--	B-21-17 23BBB
YES	10	--	--	Tv	GRC	Barkhurst	
--	45	--	--	--	USGS	--	B-21-17 23BCD
--	--	--	--	--	USGS	--	B-21-17 24BCA
--	--	--	--	Alluv(?), Tv	DR	Brazie	
--	--	--	--	--	USGS	--	B-21-17 24CAD
--	--	--	--	--	USGS	--	B-21-17 24CBB
--	175	--	--	--	USGS	--	B-21-17 24CBC
--	--	--	--	--	USGS	--	B-21-17 24CBD
--	--	--	--	--	USGS	--	B-21-17 24CCA
--	--	--	--	--	USGS	--	B-21-17 24CCB
--	105	--	44	--	USGS	--	B-21-17 24CDA
--	200	--	--	--	USGS	--	B-21-17 24CDB
--	150	--	--	--	USGS	--	B-21-17 24CDD1
--	--	--	--	--	USGS	--	B-21-17 24CDD2
--	--	--	--	--	USGS	--	B-21-17 24DCA
--	--	--	--	--	USGS	--	B-21-17 24DCD
--	--	--	--	--	USGS	--	B-21-17 24DDC
--	--	--	--	--	USGS	--	B-21-17 25AAA
--	--	--	--	--	USGS	--	B-21-17 34ACA
--	--	--	--	--	USGS	--	B-21-17 34B
--	--	--	--	--	USGS	--	B-21-17 34BBB
--	--	--	--	--	USGS	--	B-21-17 34D
--	--	--	--	Alluv	USGS	--	B-21-17 34DAD
--	--	--	--	Alluv	USGS	--	B-21-17 34DCA
--	--	--	--	--	USGS	--	B-21-17 34DDB
--	--	--	--	--	USGS	--	B-21-17 34DDC
--	--	--	--	Alluv(?)	DR	Cunningham	B-21-17 35BBC1
--	--	--	--	Alluv(?)	DR	Cunningham	B-21-17 35BBC2
--	--	--	--	Alluv(?)	DR	Cunningham	B-21-17 35BBC3
--	--	--	--	Alluv(?)	DR	Cunningham	B-21-17 35BBC4
--	--	--	--	--	USGS	--	B-21-17 35BD
--	--	--	--	--	USGS	--	B-21-17 35C
--	--	--	--	--	USGS	--	B-21-17 35CAA
--	--	--	--	--	USGS	--	B-21-17 35CBD

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-21-17 35CCB	--	90	--	U	3065	66.22	02/15/52	--
B-22-13 09ABC	1944	774	8	S	3872	494.00	02/27/52	--
	--	--	--	--	--	496	1980	--
	--	600	6	--	--	--	--	04/14/82 P
B-22-13 13AAD	03/ /1980	--	8	S	4320	449.00	04/24/80	--
	--	--	6	--	--	--	--	04/14/82 P
B-22-13 24AC	08/06/1979	127	8	--	--	--	--	--
B-22-14 10DCB	1957	162	8	S	4821	128.00	01/ /57	--
B-22-14 19ADA		--	8	U	4265	32.40	02/29/80	--
B-22-14 19ADB		--	--	S	4260	--	--	--
B-22-14 22AAA		16	--	S	--	--	--	--
B-22-14 22ABB	--	--	8	U	4821	--	--	--
B-22-14 23BCC	--	200	--	S	--	--	--	--
B-22-14 30ABD	--	30	--	U	4000	--	--	--
B-22-14 30CBA	--	180	--	H	4000	110.00	01/ /65	--
B-22-15 12DDA1	--	--	6	U	4050	173.10	02/29/80	--
B-22-15 12DDA2	--	--	--	S	4050	172.80	02/29/80	--
B-22-15 12DDC	--	--	8	U	4020	68.30	02/29/80	--
B-22-15 24ADC	--	38	--	S	4000	-- D	01/26/65	--
B-22-15 24DAB	--	180	--	S	4000	--	--	--
B-22-15 33DAD	04/ /1965	1220	8	S	3687	911.57	04/29/65	--
	--	--	--	--	--	917	1980	--
B-22-15 35BDB	1963	422	8	U	3750	-- D	02/29/80	--
B-22-16 01DCC	10/ /1974	595	16	U	3234	456.60	02/29/80	--
B-22-16 03CBB	1973	970	20	H	3325	542.60	03/18/80	--
	--	--	--	--	--	544.3	01/13/82	--
B-22-16E07ADD	--	--	--	U	3460	--	--	--
B-22-16E07DAA	10/ /1977	1000	16	P	3455	670.00	10/ /77	--
B-22-16 15CCC	02/ /1970	1000	16	I	3288	497.80	03/04/80	--
B-22-16E19BAA	10/ /1965	1000	16	P	3450	664.50	03/04/80	--
B-22-16 26BAC	1967	1247	14	N	3335	551.40	02/07/67	--
	--	--	--	--	--	554	1980	--
B-22-16 27DDD	--	--	--	P	3374	--	--	--
B-22-16 28ACC	--	1000	--	H	3305	--	--	--
B-22-16 28BAD1	--	--	--	P	3301	524.40	01/22/80	--
B-22-16 28BAD2	04/ /1982	1050	8	U	3303	523.5 S	05/01/82	--

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	--	--	--	--	USGS	--	B-21-17 35CCB
--	6.6	5/19/80	--	--	USGS	--	B-22-13 09ABC
--	--	--	--	--	R	--	
YES	13	4/14/82	--	Alluv	GRC	X Bar 1 Ranch Corp.	B-22-13 13AAD
--	--	--	--	--	USGS, R	--	
YES	18.2	4/14/82	--	--	GRC	X Bar 1 Ranch Corp.	B-22-13 24AC
--	30	08/06/79	--	Br	DR	BLM (New London Well)	B-22-14 10DCB
--	--	--	--	--	USGS, R	--	
--	--	--	--	--	USGS, R	--	B-22-14 19ADA
--	--	--	--	--	USGS	--	B-22-14 19ADB
--	--	--	--	--	USGS	--	B-22-14 22AAA
--	--	--	--	--	USGS	--	B-22-14 22ABB
--	--	--	--	--	USGS	--	B-22-14 23BCC
--	1.0	--	--	--	USGS	--	B-22-14 30ABD
--	15	--	--	--	USGS	--	B-22-14 30CBA
--	--	--	--	--	USGS, R	--	B-22-15 12DDA1
--	--	--	--	--	USGS, R	--	B-22-15 12DDA2
--	0.0	--	--	--	USGS, R	--	B-22-15 12DDC
--	--	--	--	--	USGS	--	B-22-15 24ADC
--	3.0	--	--	--	USGS	--	B-22-15 24DAB
--	10	--	243	Alluv	USGS	--	B-22-15 33DAD
--	--	--	--	--	R	--	
--	--	--	--	--	USGS, R	--	B-22-15 35BDB
--	--	--	--	Alluv	USGS, R	--	B-22-16 01DCC
--	--	--	--	Alluv	USGS, R	--	B-22-16 03CBB
--	--	--	--	--	USGS	--	
--	--	--	--	--	USGS	--	B-22-16E07ADD
--	--	--	--	Alluv, Tv	USGS, R	--	B-22-16E07DAA
--	1575	3/04/80	146	Alluv	USGS, R	--	B-22-16 15CCC
--	--	--	--	Tv	USGS, R	--	B-22-16E19BAA
--	660	--	51	Alluv	USGS	--	B-22-16 26BAC
--	--	--	--	--	R	--	B-22-16 27DDD
--	700	3/19/80	--	--	USGS, R	--	B-22-16 28ACC
--	500	--	22	Alluv	USGS	--	B-22-16 28BAD1
--	--	--	--	Alluv	USGS, R	--	B-22-16 28BAD2
--	1125	5/17/82	640	Alluv	GRC, OTH	City of Kingman	

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B-22-16 33BCD	01/01/1971	1008	16	P	3350	--	--	--
B-22-16 33CDC	1971	1008	16	C	3385	--	--	--
B-22-16 34CBC	04/05/1978	1000	16	P	3399	621.00	03/03/80	--
B-22-17 01ADA	09/ /1978	480	8	U	3690	244.10	02/28/80	--
B-22-17 01DBB	06/ /1978	287	8	U	3725	251.50	02/28/80	--
B-22-17 03ABA	--	--	--	U	4140	-- F	02/28/80	--
B-22-17 04CBA	--	--	--	S	5000	--	--	--
B-22-17 04CDC	--	12	--	S	4900	8.00	1962	--
B-22-17 07CDC	--	250	7	N	3932	--	--	03/15/82 P
B-22-17 07CDD	02/26/1982	210	6	N	3852	49.4 S	03/15/82	03/15/82 S
B-22-17 09ADD1	--	289	--	S	4200	15.00	12/30/64	--
B-22-17 09ADD2	--	20	--	S	4200	16.00	12/30/64	--
B-22-17 09BDC	--	60	--	S	4700	30.00	12/30/64	--
B-22-17 10ABC	08/28/1979	205	5	S	4150	48	08/28/79	--
B-22-17 11ABA	12/10/1977	120	8	U	3845	69.20	02/28/80	--
B-22-17 11CAA	09/12/1977	130	8	H	3830	--	--	--
	--	--	--	--	3840	27	1980	--
B-22-17 11DAB	06/ /1981	I 260	4	H	--	200	--	--
B-22-17 12DDA	07/01/1977	990	8	U	3581	--	--	--
B-22-17 14BD	08/ /1980	I 175	4	H	--	75	--	--
B-22-17 14CBB	1968-70	255	10	--	--	--	--	--
B-22-17 15DAB	--	50	--	H	3950	--	--	--
B-22-17 15DDC	1968-70	165	10	--	--	--	--	--
B-22-17 19CDA	10/12/1979	325	4	--	--	260	10/12/79	--
B-22-17 22AAB1	--	--	8	U	4115	--	--	--
B-22-17 22AAB2	--	--	8	U	4118	--	--	--
B-22-17 22AAB3	--	--	8	U	4125	--	--	--
B-22-17 30CA	07/02/1979	175	5	--	--	40	07/02/79	--
B-22-17 30CCC	06/15/1979	175	6	--	--	120	06/15/79	--
B-22-17 31ABB1	--	70	--	--	3584	47.05	03/25/52	--
B-22-17 31ABB2	--	30	--	--	3584	27.35	04/15/69	--
B-22-17 33AC	--	46	--	U	4327	36.00	05/20/43	--
B-22-17 33ADA	--	50	--	S	4500	50.00	--	--
B-22-17 33DA	--	242	--	U	4303	53.00	05/20/43	--
B-22-17 34ACB	1974	275	10	--	4180	100.00	12/10/51	--
B-22-17 34BDA	1941	286	12	P	4172	11.60	08/26/42	--

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--	--	--	--	--	USGS, R	--	B-22-16 33BCD
--	--	--	--	Alluv	USGS	--	B-22-16 33CDC
--	--	--	--	Alluv	USGS, R	--	B-22-16 34CBC
--	--	--	--	Br	USGS, R	--	B-22-17 01ADA
--	--	--	--	Alluv, Br	USGS, R	--	B-22-17 01DBB
--	--	--	--	--	USGS, R	--	B-22-17 03ABA
--	--	--	--	--	USGS	--	B-22-17 04CBA
--	--	--	--	--	USGS	--	B-22-17 04CDC
YES	20	--	--	--	GRC, OWN	Amer. Internat. Mineral	B-22-17 07CDC
YES	--	--	--	--	GRC	Amer. Internat. Mineral	B-22-17 07CDD
--	10	--	--	--	USGS	--	B-22-17 09ADD1
--	30	--	--	--	USGS	--	B-22-17 09ADD2
--	--	--	--	--	USGS	--	B-22-17 09BDC
--	--	--	--	Br	USGS, DR	--	B-22-17 10ABC
--	--	--	--	Br	USGS, R	--	B-22-17 11ABA
--	--	--	--	--	USGS	--	B-22-17 11CAA
--	--	--	--	--	R	--	
--	15	--	--	--	ADWR	Fawson	B-22-17 11DAB
--	--	--	--	Alluv	USGS, R	--	B-22-17 12DDA
--	15	--	25	--	ADWR	Riccardi	B-22-17 14BD
--	--	--	--	--	DR	Jordan	B-22-17 14CBB
--	--	--	--	--	USGS	--	B-22-17 15DAB
--	--	--	--	--	DR	Jordan	B-22-17 15DDC
--	--	--	--	Br	DR	Grant	B-22-17 19CDA
--	--	--	--	--	USGS, R (?)	--	B-22-17 22AAB1
--	--	--	--	--	USGS, R (?)	--	B-22-17 22AAB2
--	--	--	--	--	USGS, R (?)	--	B-22-17 22AAB3
--	--	--	--	Br	DR	Leibold	B-22-17 30CA
--	--	--	--	Br	DR	Sisson	B-22-17 30CCC
--	--	--	--	--	USGS	--	B-22-17 31ABB1
--	--	--	--	--	USGS	--	B-22-17 31ABB2
--	--	--	--	--	USGS	--	B-22-17 33AC
--	--	--	--	--	USGS	--	B-22-17 33ADA
--	--	--	--	--	USGS	--	B-22-17 33DA
--	--	--	--	--	USGS	--	B-22-17 34ACB
--	--	--	--	--	USGS	--	B-22-17 34BDA

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B-22-17 34DBC	12/ /1943	58	--	U	3906	--	--	--
B-22-17 34DCB	--	--	--	S	4075	2.98	10/10/79	--
B-22-17 34DCC	--	25	--	U	4077	12.20	08/16/43	--
B-22-17 34DDC	1941	229	12	P	4036	98.61	04/23/69	--
B-22-18 02AAA	--	--	--	H	3660	17.48	03/25/52	--
B-22-18 03AAD	--	700	18	U	3505	<700	03/16/82	03/16/82 0
B-22-18 05AAD	11/16/1968	2510	14	--	3330	1332.00	11/16/68	--
	--	--	--	U	--	>998	03/14/82	03/14/82
B-22-18 05DBC	01/22/1969	2437	9	N	3275	1220.00	01/22/69	--
	--	--	--	U	--	>999	03/14/82	03/14/82
B-22-18 12CAA	--	50	--	U	3700	--	--	--
B-22-18 12CAB	--	--	--	S	3620	10.42	03/25/52	--
B-22-18 12DAD	--	24	--	U	3800	21.04	04/14/52	--
B-22-19 07ACB1	--	60	--	S	3530	--	--	--
B-22-19 07ACB2	--	60	--	--	3530	50.74	02/27/79	--
B-23-12 30CAB	--	--	6	S	4760	13.30	05/19/80	--
B-23-12 30DDB	--	--	--	S	4842	--	--	--
B-23-12 31BBC	1964	70	6	S	4955	25.00	03/ /64	--
	--	--	--	--	--	32	1980	--
B-23-13 02C	--	--	--	I	3800	30.34	03/05/52	--
B-23-13 02CCA	--	80	--	-	3825	19.42	02/05/52	--
B-23-13 02CCB	--	60	--	-	3825	--	--	--
B-23-13 03AD	--	120	--	P	3990	36.00	--	--
B-23-13 03DAD	--	90	--	U	3825	14.70	03/21/80	--
B-23-13 10ABA	--	53	36	U	3779	27.20	01/29/80	--
B-23-13 10BBB	--	--	--	P	3800	36.65	03/05/52	--
B-23-13 10CA	1895	--	--	I	3775	31.70	03/06/52	--
B-23-13 10DBA	--	42	--	I	3770	12.50	02/29/44	--
B-23-13 11BBB	02/ /1964	74	12	U	3850	36.90	03/21/80	--
B-23-13 16DDD	06/ /1972	128	20	P	3735	--	--	--
B-23-13 19CBB	01/ /1944	150	8	U	3595	36.90	01/19/44	--
B-23-13 19CDD	--	--	10	U	3657	128.20	01/24/80	--
	--	--	--	--	--	101	1980	--
B-23-13 19DCB	01/ /1944	150	6	U	3628	51.30	01/22/44	--
	--	--	--	--	--	61	1980	--

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--	--	--	--	--	USGS	--	B-22-17 34DBC
--	--	--	--	Tv	USGS	--	B-22-17 34DCB
--	--	--	--	--	USGS	--	B-22-17 34DCC
--	--	--	--	--	USGS	--	B-22-17 34DDC
--	--	--	--	--	USGS	--	B-22-18 02AAA
NO	--	--	--	--	USGS, GRC	--	B-22-18 03AAD
--	--	--	--	--	USGS	--	B-22-18 05AAD
NO	--	--	--	Alluv	GRC	El Paso Natural Gas	
--	--	--	--	--	USGS	--	B-22-18 05DBC
NO	--	--	--	Alluv	GRC	El Paso Natural Gas	
--	--	--	--	--	USGS	--	B-22-18 12CAA
--	--	--	--	--	USGS	--	B-22-18 12CAB
--	--	--	--	--	USGS	--	B-22-18 12DAD
--	2	--	--	--	USGS	--	B-22-19 07ACB1
--	4	--	--	--	USGS	--	B-22-19 07ACB2
--	--	--	--	--	USGS, R	--	B-23-12 30CAB
--	--	--	--	--	USGS, R	--	B-23-12 30DDB
--	5.0	--	--	--	USGS	--	B-23-12 31BBC
--	--	--	--	--	R	--	
--	--	--	--	--	USGS	--	B-23-13 02C
--	700	--	4	--	USGS	--	B-23-13 02CCA
--	225	--	--	--	USGS	--	B-23-13 02CCB
--	--	--	--	--	USGS	--	B-23-13 03AD
--	--	--	--	Alluv	USGS	--	B-23-13 03DAD
--	--	--	--	Alluv	USGS, R	--	B-23-13 10ABA
--	--	--	--	--	USGS	--	B-23-13 10BBB
--	--	--	--	--	USGS	--	B-23-13 10CA
--	500	--	--	--	USGS	--	B-23-13 10DBA
--	200	--	--	Alluv	USGS	--	B-23-13 11BBB
--	--	--	--	--	USGS	--	B-23-13 16DDD
--	--	--	--	--	USGS	--	B-23-13 19CBB
--	--	--	--	Alluv	USGS	--	B-23-13 19CDD
--	--	--	--	--	R	--	
--	--	--	--	Alluv	USGS	--	B-23-13 19DCB
--	--	--	--	--	R	--	

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-23-13 19DDA	1962	1072	16	U	3637	140.74	05/03/65	--
	--	--	--	--	--	83	1980	--
B-23-13 20CCD	02/12/1944	355	16	P	3643	52.40	03/03/44	--
B-23-13 21AAA1	05/ /1972	44	16	P	3730	21.80	01/29/80	--
B-23-13 21AAA2	05/ /1972	61	16	P	3732	--	--	--
B-23-13 21AAA3	--	--	16	U	3727	--	--	--
B-23-13 21CBD	1950	75	54	H	3700	52.99	05/06/65	--
B-23-13 22BAB	--	30	--	I	3730	15.50	10/13/43	--
B-23-13 22BBA1	01/ /1963	94	16	I	3785	20.10	02/26/80	--
B-23-13 22BBA2	--	125	16	I	3734	20.69 R	04/15/82	04/15/82 R
B-23-13 22BBB2	1972	44	16	H	--	14	--	--
B-23-13 22BBB3	1972	128	20	H	--	104	--	--
B-23-13 23CBB	--	--	20	U	3888	5.00	02/26/80	--
B-23-13 27DAB	--	150	--	S	4016	--	--	--
B-23-13 29AAA1	09/ /1929	40	8	H	3672	29.45	10/13/43	--
	--	--	--	--	--	33	1980	--
B-23-13 29AAA2	04/03/1980	270	8	--	--	12	04/03/80	--
B-23-13 29AAB	--	70	3	H,S	3673	34.9	1979	04/14/82 P
B-23-13 29AAD	04/06/1980	600	8	--	--	360	04/06/80	--
B-23-13 29ABA	03/ /1980	270	8	H,S	3652	18.7 P	04/14/82	04/14/82 P
B-23-13 29DBC1	10/ /1943	272	16	U	3704	134.50	11/12/43	--
B-23-13 29DBC2	12/ /1943	593	16	P	3704	133.90	12/23/43	--
	--	--	--	--	--	190 ?	1965	04/14/82 P
	--	--	--	--	--	192	1980	--
B-23-13 32ACA	01/29/1944	472	16	U	3768	194.78	02/29/44	--
	--	--	--	--	--	254	01/ /72	--
	--	--	--	--	--	256	03/21/80	--
	--	--	--	--	--	253.7	04/09/81	--
	--	--	--	--	--	252.9	01/13/82	--
	--	--	--	--	--	246.08	04/14/82	04/14/82
B-23-13 32DAA	11/ /1943	724	3	U	3791	255.65	11/12/43	--
	--	--	--	--	--	294	1980	--
B-23-13 35CBD1	1963	125	--	U	4199	80.00	1963	--
B-23-13 35CBD2	--	--	8	U	4200	64.50	01/24/80	--
B-23-14 03ABB	10/ /1943	75	16	U	--	-- DD	--	--

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	204	--	--	Alluv	USGS	--	B-23-13 19DDA
--	--	--	--	--	R	--	
--	580	--	80	--	USGS	--	B-23-13 20CCD
--	--	--	--	Alluv	USGS	--	B-23-13 21AAA1
--	--	--	--	--	USGS	--	B-23-13 21AAA2
--	--	--	--	--	USGS	--	B-23-13 21AAA3
--	--	--	--	--	USGS	--	B-23-13 21CBD
--	--	--	--	--	USGS	--	B-23-13 22BAB
--	30	--	--	Alluv	USGS, R	--	B-23-13 22BBA1
YES	200	04/15/82	46	Alluv	GRC	X Bar 1 Ranch Corp.	B-23-13 22BBA2
--	--	--	--	Alluv	ADWR	Neal	B-23-13 22BBB2
--	--	--	--	--	ADWR	Neal	B-23-13 22BBB3
--	--	--	--	--	USGS, R	--	B-23-13 23CBB
--	--	--	--	--	USGS, R	--	B-23-13 27DAB
--	5.0	--	--	Alluv	USGS	--	B-23-13 29AAA1
--	--	--	--	--	R	--	
--	--	--	--	Alluv	DR	X Bar 1 Ranch; Zaugg	B-23-13 29AAA2
NO	10	1979	0	Alluv	GRC, OWN	X Bar 1 Ranch Corp.	B-23-13 29AAB
--	--	--	--	Br	DR	X Bar 1 Ranch Corp.	B-23-13 29AAD
YES	30	1982	--	Alluv	GRC, OWN	X Bar 1 Ranch Corp.	B-23-13 29ABA
--	--	--	--	--	USGS	--	B-23-13 29DBC1
--	360	12/07/43	90	--	USGS	--	B-23-13 29DBC2
NO	--	--	--	Alluv	GRC, OWN	Neal	
--	--	--	--	--	R	--	
--	--	--	--	--	USGS	--	B-23-13 32ACA
--	--	--	--	--	OTH	--	
--	--	--	--	--	R	--	
--	--	--	--	--	USGS	--	
--	--	--	--	--	USGS	--	
NO	200	--	--	Alluv	GRC	Neal	
--	--	--	--	Alluv	USGS	--	B-23-13 32DAA
--	--	--	--	--	R	--	
--	5.0	--	--	--	USGS	--	B-23-13 35CBD1
--	--	--	--	--	USGS, R	--	B-23-13 35CBD2
--	--	--	--	--	USGS	--	B-23-14 03ABB

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-23-14 03ACD	11/ /1943	642	3	U	3425	514.18	04/24/65	--
B-23-14 03ADC	11/ /1943	491	16	U	3428	456.00	11/10/43	--
	--	--	--	--	--	480	1980	--
	--	--	--	--	--	484.2	04/15/82	04/15/82
B-23-14 03BBB	03/ /1944	5	6	Z	3450	-- DD	--	--
B-23-14 13CCB1	--	103	--	U	3550	63.00	05/23/32	--
B-23-14 13CCB2	06/ /1922	89	16	U	3550	50.94	11/11/43	--
B-23-14 13CCB3	04/ /1919	104	16	U	3550	51.36	11/11/43	--
B-23-14 13CCB4	08/ /1925	91	16	U	3550	62.00	06/23/32	--
B-23-14 13CCB5	1900	87	16	U	3550	62.00	06/23/32	--
B-23-14 13CCC1	--	80	--	U	3565	51.72	11/23/43	--
B-23-14 13CCC2	--	75	72	U	3566	50.45	11/23/43	--
B-23-14 13CCC3	--	--	6	H	3565	--	--	--
B-23-14 24BAB1	09/ /1962	290	8	U	3562	60.00	01/12/65	--
B-23-14 24BAB2	1962	222	20	U	3562	68.56	04/29/65	--
	--	--	--	--	--	69	1980	--
B-23-14 33DAD	06/ /1961	107	8	S	4790	34.90	01/25/80	--
B-23-15 04DDD	09/25/1972	805	16	P	3175	455.00	09/25/72	--
	--	--	--	--	--	585 P	05/06/82	05/06/82 P
B-23-15 08CDA	05/ /1964	600	16	I	3085	368.50	03/18/65	--
	--	--	--	--	--	367	1980	--
B-23-15 08DDD	1964	929	20	P	3130	402.90	05/03/65	--
	--	--	--	--	--	406	1980	--
B-23-15 24BB	09/05/1962	290	11	--	--	--	--	--
B-23-15 28CDD	05/ /1917	1040	7	--	3270	489.00	05/ /65	--
B-23-15 30CBB	06/15/1973	1000	20	U	3153	380.00	05/15/73	--
B-23-16E07BDA	03/ /1978	430	4.5	H	3650	168.60	03/12/80	--
B-23-16 09BCB	03/28/1980	710	4	U	3358	612.50	05/23/80	--
B-23-16 09BDA	--	625	6	U	3325	--	--	--
B-23-16 15BDB	1965	840	10	S	3295	538.30	03/18/80	--
B-23-16 17ACD	--	--	--	U	3453	106.80	03/12/80	--
B-23-16 17CDA	03/18/1978	290	6.63	U	3480	92.60	03/12/80	--
B-23-16 17DDA	05/17/1980	160	--	--	--	65	05/17/80	--
B-23-16 17DDC1	03/22/1978	320	6.63	H	3465	98.70	03/12/80	--
B-23-16 17DDC2	1981	290	5	H	--	95	--	--
B-23-16 21CDD	1981	360	5	H	--	250	--	--

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	--	--	--	--	USGS	--	B-23-14 03ACD
--	--	--	--	--	USGS	--	B-23-14 03ADC
--	--	--	--	--	R	--	
NO	--	--	--	Alluv	GRC	BLM	
--	--	--	--	--	USGS	--	B-23-14 03BBB
--	220	--	0	--	USGS	--	B-23-14 13CCB1
--	35	--	--	--	USGS	--	B-23-14 13CCB2
--	85	--	--	--	USGS	--	B-23-14 13CCB3
--	25	--	--	Br	USGS	--	B-23-14 13CCB4
--	25	--	--	--	USGS	--	B-23-14 13CCB5
--	--	--	--	--	USGS	--	B-23-14 13CCC1
--	--	--	--	--	USGS	--	B-23-14 13CCC2
--	--	--	--	--	USGS	--	B-23-14 13CCC3
--	50	--	32	--	USGS	--	B-23-14 24BAB1
--	100	--	55	Alluv	USGS	--	B-23-14 24BAB2
--	--	--	--	--	R	--	
--	--	--	--	--	USGS, R	--	B-23-14 33DAD
--	160	--	--	--	USGS	--	B-23-15 04DDD
YES	128	5/6/82	--	Alluv	GRC	Neal	
--	1200	--	35	Alluv	USGS	--	B-23-15 08CDA
--	--	--	--	--	R	--	
--	1000	--	110	Alluv	USGS	--	B-23-15 08DDD
--	--	--	--	--	R	--	
--	--	--	--	Alluv	DR	Grounds	B-23-15 24BB
--	--	--	--	--	USGS	--	B-23-15 28CDD
--	--	--	--	Alluv	USGS	--	B-23-15 30CBB
--	--	--	--	--	USGS, R	--	B-23-16E07BDA
--	--	--	--	Alluv	USGS, R	--	B-23-16 09BCB
--	--	--	--	--	USGS, R	--	B-23-16 09BDA
--	550	--	20	Alluv	USGS, R	--	B-23-16 15BDB
--	--	--	--	--	USGS, R	--	B-23-16 17ACD
--	1.0	3/18/78	--	Br	USGS	--	B-23-16 17CDA
--	--	--	--	Br	DR	Leuser	B-23-16 17DDA
--	2.0	3/22/78	--	Br	USGS, R	--	B-23-16 17DDC1
--	6	--	--	--	ADWR	Brown	B-23-16 17DDC2
--	10	--	--	--	ADWR	Gustafson	B-23-16 21CDD

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B-23-17 02BCC	--	--	--	U	4120	8.00	03/12/80	--
B-23-17 11BDA	--	--	--	U	4180	--	--	--
B-23-17 11CAA	--	--	--	U	4150	--	--	--
B-23-17 13ADB	--	--	--	U	3920	--	--	--
B-23-17 15ABB1	--	150	--	S	4371	27.40	02/27/80	--
B-23-17 15ABB2	01/ /1968	--	--	U	4366	57.60	02/27/80	--
B-23-17 15ABB3	01/ /1973	127	--	U	4366	26.80	02/27/80	--
B-23-17 20BDD	--	40	--	U	4900	30.00	1964	--
B-23-17 24ADD	1960	--	--	S	3789	75.20	03/20/80	--
B-23-17 25DC	1980	500	--	H	--	450	--	--
B-23-17 28AAB	1960	25	--	U	4469	5.50	02/27/80	--
B-23-17 33DDB	--	15	--	S	4600	12.00	1964	--
B-23-17 35BDB	05/22/1980	295	4	U	3995	102.50	05/23/80	--
B-23-18 03ADB	1961	145	8	P	4140	115.00	03/ /65	--
B-23-18 03BCA	1959	210	10	P	4020	--	--	--
B-23-18 04AAC	--	78	--	P	4000	30.00	03/ /65	--
B-23-18 04ADA	1966	256	--	P	4025	31.00	02/07/79	--
B-23-18 04ADD	1958	104	8	P	3990	40.46	02/06/79	--
B-23-18 05BDC	--	30	--	S	3830	--	--	05/05/82 DD
B-23-18 06AAD	--	92	9	U	3845	29.7	25/05/82	05/05/82
B-23-18 06ADB	04/08/1969	300	8	H	3805	225	1969	--
B-23-18 09AAD	1965	104	10	U	3900	61.00	10/ /65	--
B-23-18 09ABD	--	70	--	S	3825	--	--	--
B-23-18 09BCC	--	49	--	S	3759	8.65	03/06/79	--
B-23-18 10DCC	1966	264	--	N	3870	--	--	--
B-23-18 14AAC	--	33	--	S	4400	28.00	10/ /64	--
B-23-18 15ACB	06/16/1966	170	8	--	3850	72.00	06/18/66	--
	--	--	--	U	--	52.7	05/05/82	05/05/82
B-23-18 15BAA	1966	200	10	--	3830	110.00	05/ /66	--
	06/15/1967	--	--	U	--	24.5	05/05/82	05/05/82
B-23-18 20AAA	08/20/1977	375	8	U	3620	-- D	05/05/82	05/05/82 D
B-23-18 21BCB1	09/ /1981	320	6	U	3610	-- D	09/ /81	05/05/82 O
B-23-18 21BCB2	09/ /1981	600	8	U	3610	-- D	05/05/82	05/05/82
B-23-18 22	--	225	--	--	3700	77.00	03/ /63	--
B-23-18 23BCD	--	150	--	S	3900	33.25	03/06/79	--
B-23-18 27ADA	--	350	--	N	--	--	--	--
B-23-18 32DAD1	08/12/1968	2132	8	--	3380	1225.00	08/12/68	--
	--	--	9	U	--	--	--	03/14/82 O

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	--	--	--	--	USGS, R	--	B-23-17 02BCC
--	--	--	--	--	USGS, R (?)	--	B-23-17 11BDA
--	--	--	--	--	USGS, R (?)	--	B-23-17 11CAA
--	--	--	--	--	USGS	--	B-23-17 13ADB
--	--	--	--	--	USGS	--	B-23-17 15ABB1
--	--	--	--	--	USGS	--	B-23-17 15ABB2
--	--	--	--	--	USGS, R	--	B-23-17 15ABB3
--	--	--	--	--	USGS	--	B-23-17 20BDD
--	--	--	--	--	USGS, R	--	B-23-17 24ADD
--	2	--	--	--	ADWR	Neal	B-23-17 25DC
--	--	--	--	--	USGS, R	--	B-23-17 28AAB
--	3.0	--	--	--	USGS	--	B-23-17 33DDB
--	--	--	--	Alluv, Br	USGS, R	--	B-23-17 35BDB
--	15	--	--	--	USGS	--	B-23-18 03ADB
--	15	--	--	--	USGS	--	B-23-18 03BCA
--	15	--	--	--	USGS	--	B-23-18 04AAC
--	15	--	--	--	USGS	--	B-23-18 04ADA
--	15	--	10	--	USGS	--	B-23-18 04ADD
NO	--	--	--	Alluv	USGS, GRC	--	B-23-18 05BDC
YES	--	--	--	--	GRC	--	B-23-18 06AAD
NO	--	--	--	Alluv	GRC, DR	Collins	B-23-18 06ADB
--	1	--	--	--	USGS	--	B-23-18 09AAD
--	5	--	--	--	USGS	--	B-23-18 09ABD
--	--	--	--	Alluv	USGS	--	B-23-18 09BCC
--	--	--	--	--	USGS	--	B-23-18 10DCC
--	--	--	--	--	USGS	--	B-23-18 14AAC
--	100	--	59	--	USGS	--	B-23-18 15ACB
NO	--	--	--	Br	GRC	El Paso Natural Gas	
--	70	--	--	--	USGS	--	B-23-18 15BAA
YES	--	--	--	Br	GRC	El Paso Natural Gas	
NO	--	--	--	Br	GRC	BLM (Tennessee Wash Well)	B-23-18 20AAA
NO	--	--	--	Br	GRC, OWN	Melbourn	B-23-18 21BCB1
NO	--	--	--	Br	GRC	Melbourn	B-23-18 21BCB2
--	--	--	--	--	USGS	--	B-23-18 22
--	5	--	--	Br	USGS	--	B-23-18 23BCD
--	30	--	--	--	USGS	--	B-23-18 27ADA
--	150	--	--	--	USGS	--	B-23-18 32DAD1
NO	--	--	--	Alluv	GRC	El Paso Natural Gas	

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-23-18 32DAD2	--	--	16	U	3378	--	--	03/14/82 O
B-23-18 33CBC	1968	1357	--	U	3380	--	--	--
	--	--	--	--	--	800 ?	1981	--
B-23-18 34ADC	1965	--	--	U	3576	240.00	05/ /65	--
B-23-18 34BDD	1967	320	6	U	--	46.00	11/29/67	--
B-23-18 35CCC	1973	170	12	N	3530	65.00	08/01/73	--
B-23-18 35DCC	--	56	14	U	3616	25.6	03/16/82	03/16/82
B-23-18 36BAD	--	400	--	S	3850	40.00	01/ /65	--
B-23-19 10ACA	--	80	64	U	3369	-- D	05/04/82	05/04/82 D
B-23-19 12ACD	07/ /1980	838	8	U	3543	-- D	05/04/82	05/04/82 D
B-23-19 16CC	09/14/1979	300	--	U	3530	-- D	09/14/79	--
B-23-20 11CBA	--	69	8	U	3389	-- D	05/03/82	05/03/82 D
B-23-20 12DBA	--	--	12	U	3488	--	--	05/03/82 O
B-24-12 17ACB	--	--	--	I	4261	178.70	04/21/80	--
B-24-12 17CBC	--	440	--	U	4255	146.85	07/23/53	--
	--	--	--	--	--	144	1980	--
B-24-12 17CDD	--	--	8	S	4242	149.40	04/21/80	--
B-24-12 19ABB	--	--	--	S	4215	122.30	04/21/80	--
B-24-13 34ADD1	--	--	--	U	3885	--	--	--
B-24-13 34ADD2	--	--	6	H	3885	55.60	03/24/80	--
B-24-13 35B1	07/ /1919	101	16	N	--	24.00	07/ /19	--
B-24-13 35B2	08/27/1920	62	16	N	--	12.00	08/27/20	--
B-24-13 35DCB	11/ /1962	184	12	I,H	3927	8.20	03/24/80	--
B-24-14 04CCA	--	577	--	U	3299	322.00	03/19/80	--
B-24-14 28CAD	1943	705	16	U	3353	500.12	10/12/43	--
	--	--	--	--	--	542.3	03/19/80	--
	--	--	--	--	--	537.1	04/09/81	--
	--	--	--	--	--	544.5	01/13/82	--
	--	--	--	--	--	542.9	04/15/82	04/15/82
B-24-14 29AAA	07/ /1944	700	16	U	3318	592.60	07/14/44	--
	--	--	--	--	--	616	1980	--
	--	--	--	--	--	>603	04/15/82	04/15/82
B-24-14 29ACB	03/01/1944	949	5	U	3325	564.90	03/19/80	--
B-24-14 33ADA	06/ /1944	560	16	U	3375	521.55	04/29/65	--
	--	--	--	--	--	547	1980	--
B-24-15 11AAA	01/ /1963	492	24	U	3135	-- D	05/ /65	--
	--	--	--	--	--	-- D	1980	--
B-24-15 32ACA	08/04/1974	850	20	--	--	515	08/04/74	--
B-24-15 32BBD	04/09/1974	677	10	--	--	510	04/09/74	--
B-24-15 33BBB	02/ /1973	1100	16	U	3020	514.10	04/29/80	--

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
NO	--	--	--	Alluv	GRC	El Paso Natural Gas	B-23-18 32DAD2
--	--	--	--	--	USGS	--	B-23-18 33CBC
NO	--	--	--	Alluv	GRC, OWN	Wilcox	
--	--	--	--	--	USGS	--	B-23-18 34ADC
--	--	--	--	--	USGS	--	B-23-18 34BDD
--	--	--	--	Alluv	USGS	--	B-23-18 35CCC
YES	--	--	--	--	GRC	Duvall Corp.	B-23-18 35DCC
--	5	--	--	--	USGS	--	B-23-18 36BAD
NO	--	--	--	--	GRC	Hamilton	B-23-19 10ACA
NO	--	--	--	--	GRC	Morrison	B-23-19 12ACD
--	--	--	--	Tv	DR	BLM (Sugarloaf Well)	B-23-19 16CC
YES	--	--	--	--	GRC	--	B-23-20 11CBA
NO	--	--	--	--	GRC	--	B-23-20 12DBA
--	--	--	--	--	USGS, R	--	B-24-12 17ACB
--	--	--	--	--	USGS	--	B-24-12 17CBC
--	--	--	--	--	R	--	
--	--	--	--	--	USGS, R	--	B-24-12 17CDD
--	--	--	--	--	USGS, R	--	B-24-12 19ABB
--	--	--	--	--	USGS	--	B-24-13 34ADD1
--	--	--	--	--	USGS, R	--	B-24-13 34ADD2
--	20	--	--	Br or Tv	USGS	--	B-24-13 35B1
--	37	--	31	Br or Tv	USGS	--	B-24-13 35B2
--	--	--	--	Alluv	USGS, R	--	B-24-13 35DCB
--	--	--	--	--	USGS, R	--	B-24-14 04CCA
--	--	--	--	--	USGS	--	B-24-14 28CAD
--	--	--	--	--	R	--	
--	--	--	--	--	USGS	--	
--	--	--	--	--	USGS	--	
YES	--	--	--	Alluv	GRC	X Bar 1 Ranch Corp.	B-24-14 29AAA
--	--	--	--	--	USGS	--	
--	--	--	--	--	R	--	
NO	--	--	--	Alluv	GRC	X Bar 1 Ranch Corp.	B-24-14 29ACB
--	--	--	--	Alluv	USGS, R	--	
--	430	--	36	Alluv	USGS	--	B-24-14 33ADA
--	--	--	--	--	R	--	
--	--	--	--	Alluv	USGS	--	B-24-15 11AAA
--	--	--	--	--	R	--	
--	--	--	--	Alluv	DR	W.F. Cattle	B-24-15 32ACA
--	--	--	--	Alluv	DR	W.F. Cattle	B-24-15 32BBD
--	--	--	--	Alluv	USGS, R	--	B-24-15 33BBB

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-24-16 01DDD	1965	--	--	I,H	2961	451.37	04/28/65	--
	--	--	--	--	--	449.5	01/28/80	--
	--	--	--	--	--	449.3	05/09/81	--
	--	--	--	--	--	451.7	01/13/82	--
B-24-16 11DDD	08/22/1974	595	16	U	2938	430.90	02/28/80	--
B-24-16 17CCC	1981	520	--	--	--	-- D	--	--
B-24-16W19CDD	--	--	8	U	3370	--	--	--
B-24-16 33BAB	1980	580	8	U	3185	-- D	04/24/82	04/24/82 D
B-24-17 10CBD	--	100	--	S	3550	25.00	12/ /64	--
B-24-17 10CCA	1948	375	8	H,S	3490	200	1981	--
B-24-17 10CCB	--	30	--	H	3390	25.00	12/ /64	--
	1881	--	54	--	--	5	1981	--
B-24-17 14CDD1	--	40	8	S	3437	30.00	12/ /64	--
	1946	280	--	--	--	55	1978	--
B-24-17 14CDD2	--	40	8	U	3440	10.60	02/27/80	--
B-24-17 17CCC	--	70	--	S	3900	20.00	12/ /64	--
B-24-17 35CAB	--	400	--	U	3745	112.50	03/12/80	--
B-24-18 21AA	09/22/1979	80	6	--	4450	32	09/22/79	--
B-24-18 32CAC	--	--	--	H	3950	--	--	03/16/82 P
B-24-18 33BBA	--	--	--	U	4242	--	--	03/16/82 O
B-24-18 34CAA1	01/10/1970	350	6	--	4242	303	01/10/70	--
B-24-18 34CAA2	07/ /1981	I 550	--	H	--	280	--	--
B-24-18 34CAB	05/14/1975	350	6	P	4260	145.00	04/27/78	--
	--	--	--	--	--	72	05/14/75	--
B-24-19 08AAD	--	50	60	U	3150	-- D	05/03/82	05/03/82 D
B-24-21 10DDA	--	27	6	U	3835	13.28	05/03/82	05/03/82
B-24-21 10DDB	--	--	10	S	3875	22.58 P	05/03/82	05/03/82 P
B-24-21 11CCD1	--	--	9	S	3805	--	--	05/03/82 P
B-24-21 11CCD2	--	120	6	U	3807	58.72	05/03/82	05/03/82
B-25-12 36ACB	01/ /1972	855	10	U	4590	535.40	04/23/80	--
B-25-13 35DC	01/26/1980	150	8	--	4780	8.00	01/26/80	--
B-25-13 36CAC	--	--	72	U	4680	3.00 X	05/20/80	--
B-25-14 15BAB	01/13/1979	303	5.5	H,S	3965	156.60	09/24/80	04/22/82 O
B-25-16 30CDA	10/11/1961	600	8	U	2945	437.95	07/28/65	--
	--	--	--	--	--	439	1980	--
B-25-17 17BAD	11/ /1967	220	10	S	3159	44.20	03/20/80	--
B-25-17 17DBD	11/ /1967	220	10	S,H	--	70	11/ /67	--

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN)	AND DATE MEASURED	DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	800	--	--	Alluv	USGS	--	B-24-16 01DDD
--	--	--	--	--	R	--	
--	--	--	--	--	USGS	--	
--	--	--	--	--	USGS	--	
--	--	--	--	Alluv	USGS, R	--	B-24-16 11DDD
--	--	--	--	--	ADWR	Bozzo	B-24-16 17CCC
--	--	--	--	--	USGS, R	--	B-24-16W19CDD
NO	--	--	--	Alluv	GRC	Chapman, Canyon Ranch	B-24-16 33BAB
--	--	--	--	--	USGS, R (?)	--	B-24-17 10CBD
NO	5.0	--	--	--	GRC, OWN	Neal	B-24-17 10CCA
--	3.0	--	--	--	USGS, R (?)	--	B-24-17 10CCB
NO	1.0	--	--	--	GRC, OWN	Neal	
--	1.0	--	10	--	USGS	--	B-24-17 14CDD1
NO	.5	--	--	--	GRC, OWN	Neal	
--	--	--	--	--	USGS, R	--	B-24-17 14CDD2
--	5.0	--	--	--	USGS	--	B-24-17 17CCC
--	2.0	--	--	--	USGS, R	--	B-24-17 35CAB
--	25	9/22/79	--	Br	DR	BLM (Calico Peak Well)	B-24-18 21AA
NO	5.0	3/16/82	--	--	USGS, GRC	--	B-24-18 32CAC
NO	--	--	--	Br	GRC	--	B-24-18 33BBA
--	--	--	--	Br	DR	BLM	B-24-18 34CAA1
--	30	60	--	--	ADWR	Chloride Water	B-24-18 34CAA2
--	--	--	--	--	USGS	--	B-24-18 34CAB
--	--	--	--	Br	DR	Chloride Water Corp.	
NO	--	--	--	Alluv	GRC	Hamilton	B-24-19 08AAD
NO	--	--	--	--	GRC	Hamilton	B-24-21 10DDA
YES	4.1	5/3/82	--	--	GRC	Hamilton	B-24-21 10DDB
NO	1.8	5/3/82	--	--	GRC	Hamilton	B-24-21 11CCD1
NO	--	--	--	--	GRC	Hamilton	B-24-21 11CCD2
--	60	--	213	--	USGS, R	--	B-25-12 36ACB
--	30	1/26/80	--	--	USGS	BLM (Section 35 Well)	B-25-13 35DC
--	--	--	--	--	USGS, R	--	B-25-13 36CAC
YES	30	1/13/79	--	Br	USGS, R, GRC	Tesari	B-25-14 15BAB
--	--	--	--	Alluv	USGS	--	B-25-16 30CDA
--	--	--	--	--	R	--	
--	10	11/ /67	--	--	USGS, R	--	B-25-17 17BAD
--	10	11/ /67	35	--	ADWR, DR	Neal	B-25-17 17DBD

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)		DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION	
B-25-19 01BAB	02/23/1972	600	8	P	3430	410	R	10/ /81	04/21/82	P
B-25-19 01BDA	02/15/1968	525	6	H	3441	398.8		03/ /68	03/31/82	P
B-25-19 03CCC	05/24/1978	715	6	H	3122	588		07/ /81	03/31/82	P
B-25-19 11CBD	01/28/1978	700	6	H	3277	615		01/ /78	03/31/82	P
B-25-19 17CDD	05/30/1967	--	8	H	3020	770.00		05/ /67	--	
	--	840	9	U	--	--		--	04/21/82	
B-25-19 29DCB	1981	436	12	U	3063	--	D	04/04/82	04/04/82	D
B-25-19 30AAA	04/03/1966	--	6	H	3000	765.00		04/ /66	--	
	--	955	--	--	--	738	?	1979	04/04/82	P
B-25-19 30BAD	05/23/1966	825	8	U	2954	>670		04/04/82	04/04/82	
B-25-19 30BBA	1966	--	12	H	2950	705.00		05/ /66	--	
B-25-19 31AAA	11/26/1973	880	8	U	3017	790		1973	04/04/82	O
B-25-20 15AAA	1960	1100	8	S	2815	599	?	--	03/31/82	P
B-25-20 15DAD	--	730	7	H	2859	629	?	--	03/31/82	P
B-25-21 03ABA	--	--	2.5	S	4258	6.8	P	04/03/82	04/03/82	P
B-25-21 26BAB	--	457	7.5	U	4131	30.2		03/27/82	03/27/82	
B-25-21 27ABA	1981	254	48	U	4397	29.6		03/27/82	03/27/82	
B-25-21 35DAB	1979	180	8	S	3711	119	?	1979	03/27/82	P
B-25-22 29DDD	1961	--	12	P	780	87.00		1961	--	
B-25-22 31DCD	--	--	--	I	--	--		--	--	
B-25-22 33CCC	1963	--	8	P	800	175.00		01/ /63	--	
B-26-14 09CDB	1968	480	6	S	5650	--		--	04/11/82	DD
B-26-14 16BAB	--	--	7	S	5409	--			04/12/82	O,R
B-26-14 27DBC	--	300(?)	8	S	5128	160 (?)		04/12/82	04/12/82	
B-26-14 30CCB	--	100	8	S	4041	35.90		02/13/80	--	
	--	--	9	U	--	--		--	04/17/82	P
B-26-14 36DAC	--	--	7	U	4995	10.1		04/12/82	04/12/82	
B-26-15 23CDB	12/ /1967	180	10	S,H	--	60		12/ /67	--	
B-26-15 23DAB	1971	400	10	S	3783	241.00		--	--	
B-26-15 23DAC	1971	400	10	S	3783	241.00		1971	04/17/82	P
	--	--	--	--	--	123		1980	--	
B-26-15 24CBD	--	--	6	U	3917	--		--	--	
	--	--	7	--	--	--		--	04/17/82	DD
B-26-15 25DDA	03/ /1981	I 200	5	H	--	68		--	--	

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN)	AND DATE MEASURED	DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
YES	53	4/21/82	142	Alluv	GRC, OWN	Mt. Tipton Water Co.	B-25-19 01BAB
YES	40-50(?)	3/31/82	0(?)	Alluv	GRC, OWN	Sandberg, Larange, Smith	B-25-19 01BDA
YES	128	--	0	Alluv	GRC, OWN	Bates	B-25-19 03CCC
YES	--	--	--	Alluv	GRC, OWN	Knox	B-25-19 11CBD
--	--	--	--	--	USGS	--	B-25-19 17CDD
NO	--	--	--	Alluv	GRC	McKellar, Troemper	
NO	--	--	--	Alluv	GRC	--	B-25-19 29DCB
--	--	--	--	--	USGS	--	B-25-19 30AAA
YES	58.3	--	--	Alluv	GRC, OWN	Windolf	
NO	--	--	--	Alluv	GRC	Billman	B-25-19 30BAD
--	--	--	--	Alluv	USGS	--	B-25-19 30BBA
NO	--	--	--	Alluv	GRC, DR	Cooper	B-25-19 31AAA
NO	--	--	--	Alluv	GRC, OWN	Gustafson	B-25-20 15AAA
YES	--	--	--	Alluv	GRC, OWN	De Coopman	B-25-20 15DAD
YES	0.4	4/3/82	--	Br	GRC	BLM	B-25-21 03ABA
NO	--	--	--	Br	GRC	BLM (Coyote Well)	B-25-21 26BAB
YES	--	--	--	Br	GRC	Ishom	B-25-21 27ABA
YES	1.25	--	--	--	GRC, OWN	BLM, Sloan	B-25-21 35DAB
--	15	--	--	--	USGS,	--	B-25-22 29DDD
--	--	--	--	--	USGS,	--	B-25-22 31DCD
--	--	--	--	--	USGS,	--	B-25-22 33CCC
NO	3	--	--	--	USGS, GRC	BLM	B-26-14 09CDB
YES	--	--	--	--	GRC	BLM	B-26-14 16BAB
NO	--	--	--	--	GRC	BLM	B-26-14 27DBC
--	--	--	--	--	USGS, R	--	B-26-14 30CCB
YES	2.0	--	--	--	GRC	Neal	
YES	--	--	--	--	GRC	BLM	B-26-14 36DAC
--	20	12/ /67	60	--	DR	Neal	B-26-15 23CDB
--	--	--	--	--	USGS	--	B-26-15 23DAB
YES	.8	4/17/82	--	Br	USGS, GRC	Neal	B-26-15 23DAC
--	--	--	--	--	R	--	
--	--	--	--	--	USGS, R	--	B-26-15 24CBD
NO	--	--	--	--	GRC	Neal	
--	--	--	--	--	ADWR	Neal	B-26-15 25DDA

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-26-16 22CC	07/ /1970	5994	--	--	2805	--	--	--
B-26-16 26C	--	--	2.5	--	2835	--	--	--
B-26-16 28DDC	1958	2135	4	--	2814	-- DD	--	--
B-26-16 29BBB	--	650	16	U	2778	282.30	03/20/80	--
B-26-16 29DDD	--	710	16	U	2804	305.50 R	03/20/80	--
B-26-16 30DDD	1958	2608	4	--	2788	-- DD	--	--
B-26-17 19DCD	1971	185	8	S	3200	81.30	05/02/72	--
	--	--	--	--	--	77	1980	--
B-26-17 23BBC1	1980	600	--	--	--	--	--	--
B-26-17 23CCC	10/ /1957	700	14	U	2762	261.80	02/28/58	--
	--	--	--	--	--	262	1980	--
B-26-17 25BBB	1980	600	--	--	--	375	--	--
B-26-17 27ACA	10/ /1956	613	6	U	2782	289.10	03/25/80	--
B-26-17 35AAA	1957	800	16	S	2768	265.70	02/28/58	--
	--	--	--	--	--	267	1980	--
B-26-18 01BDB	1978	740	8	H	3302	634.80	03/19/80	--
B-26-18 03AAA1	--	705	6	H	3300	553.60	03/20/80	--
	--	--	--	--	--	560.3	01/13/82	--
B-26-18 03AAA2	10/19/1977	665	6	H	3307	570	10/19/77	--
B-26-18 05DBB	08/ /1978	700	6	H	3540	563.40	03/20/80	--
B-26-18 11DDD	1969	75	8	U	3660	-- D	03/04/80	--
B-26-18 17ABA	--	691	4	H	3560	--	--	--
B-26-18 24DAC	--	--	8	U	3570	20.30	03/06/80	--
B-26-18 31BDB1	07/14/1962	356	8	P	3690	136	1967	05/04/82 R,O
B-26-18 31BDB2	05/01/1972	147 H	2	P	3750	-- F	05/04/82	05/04/82 F
B-26-18 31BDC	1962	--	8	H	3680	132.00	--	--
B-26-19 02BAD	--	35	--	U	3980	33.00	01/ /65	--
	--	--	8	S	3980	--	--	04/21/82 P
B-26-19 03ACD	--	76	8.5	U	3949	60.99	04/21/82	04/21/82
B-26-19 25AAC	08/09/1977	150	8	H	3525	110	08/09/77	05/04/82 O
B-26-19 35AB	1966	--	6	H	3440	--	--	--
B-26-19 35DDA	09/03/1966	480	8	P	3357	330	09/03/66	04/21/82 P
B-26-19 36CCB	06/20/1978	500	7	P	3363	348	06/20/78	04/21/82 P
B-26-20 31BBD	--	--	6	U	3206	--	--	04/03/82 DD
B-26-21 15ADA	09/05/1980	425	7	U	3009	-- D	04/02/82	04/02/82 D

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
--	--	--	--	--	ABM	El Paso Natural Gas	B-26-16 22CC
--	--	--	--	--	USGS	--	B-26-16 26C
--	--	--	--	--	USGS, ABM	Kerr-McGee	B-26-16 28DDC
--	--	--	--	Alluv	USGS, R	--	B-26-16 29BBB
--	--	--	--	Alluv	USGS, R	--	B-26-16 29DDD
--	--	--	--	--	USGS, ABM	Kerr-McGee	B-26-16 30DDD
--	--	--	--	Br	USGS	--	B-26-17 19DCD
--	--	--	--	--	R	--	
--	--	--	--	--	ADWR	Carson Water Co.	B-26-17 23BBC1
--	2200	--	68	Alluv	USGS	--	B-26-17 23CCC
--	--	--	--	--	R	--	
--	--	--	--	--	ADWR	Carson Water Co.	B-26-17 25BBB
--	--	--	--	Alluv	USGS, R	--	B-26-17 27ACA
--	1500	--	--	Alluv	USGS	--	B-26-17 35AAA
--	--	--	--	--	R	--	
--	8.0	5/21/80	6	Br	USGS, R	--	B-26-18 01BDB
--	16	3/20/80	--	Alluv	USGS, R	--	B-26-18 03AAA1
--	--	--	--	--	USGS	--	
--	7.0	10/ /77	--	Alluv	USGS, DR	Hunt	B-26-18 03AAA2
--	--	--	--	Alluv	USGS, R	--	B-26-18 05DBB
--	--	--	--	--	USGS, R	--	B-26-18 11DDD
--	--	--	--	--	USGS, R	--	B-26-18 17ABA
--	--	--	--	--	USGS, R	--	B-26-18 24DAC
NO	20	1982	0	Br	GRC, OWN	Lake Mohave Ranchos Water	B-26-18 31BDB1
NO	25	--	--	Br	GRC, OWN	Lake Mohave Ranchos Water	B-26-18 31BDB2
--	--	--	--	--	USGS	--	B-26-18 31BDC
--	2.0	--	--	--	USGS	--	B-26-19 02BAD
YES	.5	4/21/82	--	--	GRC	BLM, Sloan	
YES	--	--	--	--	GRC	Sloan	B-26-19 03ACD
YES	--	--	--	Alluv	GRC, DR	Demattos	B-26-19 25AAC
--	90	--	--	--	USGS	--	B-26-19 35AB
YES	100	1982	0	Alluv	GRC, DR, OWN	Lake Mohave Ranchos Water	B-26-19 35DDA
YES	83	1982	0	Alluv	GRC, DR, OWN	Lake Mohave Ranchos Water	B-26-19 36CCB
NO	--	--	--	--	GRC	BLM	B-26-20 31BBD
NO	2.0	9/05/80	--	Br	GRC, DR	BLM (Mockingbird Well)	B-26-21 15ADA

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-26-21 26CCB	--	--	--	S	3698	36.47	04/03/82	04/03/82
B-27-14 31ADD	1968	772	6	U	5480	381.00	10/ /69	04/11/82 DD
B-27-15 02DDD	--	45	6	U	5200	-- D	04/11/82	04/11/82 D
B-27-15 04CCA	1968	634	8	U	--	575.00	10/ /69	--
	--	--	8.5	--	--	625.1	04/23/82	04/23/82
B-27-16 25DBD	--	--	--	--	3085	--	--	04/16/82 DD
B-27-16 29CCD	--	59	8	U	2758	-- D	03/25/80	--
B-27-16 33BAA	1963	500	8	U	2792	357.05	04/28/65	--
	--	--	--	--	--	352	1980	--
B-27-17 19CCA1	--	--	--	U	3082	--	--	--
	Well does not exist. There is only one well (19CCA2) in this section.							05/06/82
B-27-17 19CCA2	08/ /1965	640	12	S,H	3082	503.40	03/06/80	05/06/82 O
B-27-17 23CAC1	05/ /1973	800	20	U	2765	375.80	02/13/80	04/24/82 O
	--	--	--	--	--	381	05/ /73	--
B-27-17 23CAC2	06/ /1973	610	20	U	2757	380	06/ /73	-- DD
B-27-18 07CBD1	--	65	6	U	4000	35.00	1950	--
	--	--	--	--	--	52	1980	--
	--	51	6.5	--	--	33.1 S	04/24/82	04/24/82 S
B-27-18 07CBD2	--	65	6	S	4000	35.00	1964	--
	--	--	--	--	--	52	1980	--
	--	--	7	--	--	--	--	04/24/82 P
B-27-19 11DDA	--	94	9	U	4275	36.8	03/20/82	03/20/82
B-27-19 12ACD	--	45	--	S	4160	40.00 ?	1964	--
	--	--	--	--	--	6	1980	--
	--	50	--	--	--	40.8 P	04/24/82	04/24/82 P
B-27-19 16BBB	01/25/1964	750	8	H	3640	630	01/25/64	03/21/82 P
B-27-19 20DCD	09/17/1980	200	7	U	3436	-- D	03/23/82	03/23/82 D
B-27-19 35BDA	--	100	--	S	4020	65.00	--	--
	--	--	8	U	--	46.5	04/21/82	04/21/82
B-27-20 14ADC	06/11/1979	615	6	N	2974	481.65 R	1980	03/21/82 P
B-27-21 14CCD	1979	262	6.5	U	2491	-- D	03/30/82	03/30/82 D
B-27-21 17ABC	01/ /1977	28.1	4	U	3060	-- D	03/30/82	03/30/82 D
B-27-21 17BBC	01/18/1977	105	4	U	3043	95.75	03/30/82	03/30/82
B-27-21 20BAC	01/ /1977	236	4	U	2958	-- D	03/30/82	03/30/82 D
B-27-21 24BBB	--	79	3	U	2416	-- D	03/30/82	03/30/82 D
B-27-21 24BDC	08/14/1978	460	8	N	2418	400	1978	03/24/82 P

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
YES	--	--	--	Br	GRC	BLM	B-26-21 26CCB
NO	--	--	--	--	USGS, GRC	--	B-27-14 31ADD
NO	--	--	--	--	GRC	Hualapai Indians	B-27-15 02DDD
--	--	--	--	--	USGS	--	B-27-15 04CCA
NO	--	--	--	--	GRC	Lincoln	
NO	--	--	--	--	USGS, GRC	BLM	B-27-16 25DBD
--	--	--	--	Alluv	USGS	--	B-27-16 29CCD
--	--	--	--	Alluv	USGS	--	B-27-16 33BAA
--	--	--	--	--	R	--	
--	--	--	--	--	USGS	--	B-27-17 19CCA1
--	--	--	--	--	GRC	--	
NO	90	8/ /65	2	Alluv	USGS, R, GRC	Carson Water Co.	B-27-17 19CCA2
NO	3000	5/ /73	--	Alluv	USGS, R, GRC	Carson Water Co.	B-27-17 23CAC1
--	--	--	--	--	DR	--	
NO	--	--	--	Alluv	GRC, DR	Carson Water Co.	B-27-17 23CAC2
--	3.0	--	--	--	USGS	--	B-27-18 07CBD1
--	--	--	--	--	R(?)	--	
NO	--	--	--	--	GRC	--	
--	3.0	5/21/80	--	--	USGS	--	B-27-18 07CBD2
--	--	--	--	--	R(?)	--	
YES	.5	4/24/82	--	--	GRC	--	
YES	--	--	--	--	GRC	Controlled by Sloan	B-27-19 11DDA
--	.5	5/21/80	--	--	USGS	--	B-27-19 12ACD
--	--	--	--	--	R	--	
YES	.5	4/24/82	--	--	GRC	--	
YES	25	3/21/82	--	--	GRC, DR	Brown	B-27-19 16BBB
YES	--	--	--	Tv,Br	GRC	BLM (Little Horse Well)	B-27-19 20DCD
--	--	--	--	--	USGS	--	B-27-19 35BDA
YES	--	--	--	--	GRC	BLM, Sloan	
YES	11.0	1982	--	Br	GRC, OWN	Arizona Silver Inc.	B-27-20 14ADC
NO	--	--	--	--	GRC	GWF Oil Corp.	B-27-21 14CCD
NO	--	--	--	Br	GRC	Kunkas	B-27-21 17ABC
NO	--	--	--	Br	GRC	Kunkas	B-27-21 17BBC
NO	--	--	--	Br	GRC	Kunkas	B-27-21 20BAC
NO	--	--	--	Alluv	GRC	--	B-27-21 24BBB
YES	124.5	1982	--	Alluv	GRC, ADWR	Boulder City Aero; Tanner Co.	B-27-21 24BDC

SITE NUMBER	DATE DRILLED	WELL DEPTH (FEET)	CASING DIAMETER (INCHES)	WATER USE	ALTITUDE OF LAND SURFACE (FEET)	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED	DATE OF GRC OBSERVATION
B-27-21 24CDD	05/28/1973	464	8	H	2425	423 R	1976	03/30/82 R,O
B-27-21 25BAA	1952	470	6	H	2425	440 R	1980	03/30/82 P
B-27-21 25DDC	--	--	--	H	2460	435.00	11/ /65	--
	--	400	10	S,H	--	--	--	04/02/82 P
B-27-21 29CBA	--	74	--	U	2650	67.9	04/02/82	04/02/82
B-28-15 16BBB	--	--	--	S	5222	--	--	04/11/82 R,O
B-28-16 13CBC	--	150	--	S	5683	65 ?	07/ /81	--
B-28-16 34BDB	1952	108	8	H	4125	37.80	03/25/80	--
	--	105	--	S,H	--	63.5 ?	07/ /81	--
B-28-16 34CBA	--	--	6	U	4070	70.40	03/25/80	--
	--	110	7	--	--	77.6	04/23/82	04/23/82
B-28-17 23BAA	1971	300	8	S	3900	12.90	03/20/80	--
B-28-17 23DDD	05/07/1969	110	14	U	3840	65.57	04/22/82	04/22/82
B-28-17 31CCC	1959	800	--	U	3004	654.95	04/28/65	--
	--	--	--	--	--	654	1980	--
	--	--	--	--	--	654.1	05/27/81	--
	--	--	--	--	--	654.1	01/13/82	--
B-28-19 01BB	10/15/1979	300	--	U	3750	-- D	10/15/79	--
B-28-19 16DAC	--	250	6	U	4065	--	--	03/20/82 O
B-28-19 25ABB	09/11/1980	375	6	U	4640	57.60	09/25/80	--
B-28-20 13BAA	--	1140	7	U	3342	1120.5 ?	1972	03/21/82 O
B-28-21 03ABB	1965	1300	--	N	--	--	--	--
B-28-21 03ABC	1965	750	--	--	--	--	--	--
B-28-21 20AAC	09/25/1980	385	7	S	2310	305	09/25/80	03/23/82 P
B-28-21 26BBD	1981	500	10	N	2191	218.26 ?	10/ /81	03/24/82 P
B-29-15 08ADD	--	--	8	U	4990	193.20	09/25/80	--
B-29-15 08BDB	12/15/1979	--	8	U	4835	996.20	09/25/80	--
B-29-15 18ABA	--	528	8	U	4715	-- D	09/25/80	--
B-29-17 03DDB	11/15/1976	1365	8	--	3620	696.70	11/15/76	--
B-29-17 23CCB	10/16/1963	984	8	P	3885	935.00	10/16/63	--
	--	--	--	--	--	--	--	04/23/82 P
	--	--	--	--	--	--	--	--
B-29-17 36DDA	--	--	3	S	4492	-- F	04/23/82	04/23/82 F
B-29-18 01CCC	--	550	8	U	2190	297.70	04/28/65	--
	--	--	--	--	--	-- D	1980	--
B-29-19 20CCD	1980	1010	8	U	3158	914 ?	1980	03/21/82 O
B-29-21 35CCC	1965	250	4	S	1980	38 ?	1977	03/19/82 R,O

WATER QUALITY TESTED BY GRC	DISCHARGE (GAL/MIN) AND DATE MEASURED		DRAWDOWN (FEET)	PRODUCING FORMATION	DATA SOURCES	OWNER OR USER	SITE NUMBER
NO	33.33	1982	0	Alluv	GRC, OWN	Fauth Brothers	B-27-21 24CDD
YES	19.0	1982	0	Alluv	GRC, OWN	Kunkas	B-27-21 25BAA
--	8	--	--	--	USGS	--	B-27-21 25DDC
YES	7	1982	0	Alluv	GRC, OWN	Sloan	
YES	--	--	--	Br	GRC	Kunkas	B-27-21 29CBA
YES	--	--	--	--	GRC	Hualapai Indians	B-28-15 16BBB
NO	10	--	0	--	GRC, OWN	Linclon	B-28-16 13CBC
--	10	--	--	--	USGS, R	--	B-28-16 34BDB
NO	--	--	--	--	GRC, OWN	Lincoln	
--	--	--	--	--	USGS, R	--	B-28-16 34CBA
NO	--	--	--	--	GRC	BLM	
--	--	--	--	Br	USGS, R	--	B-28-17 23BAA
NO	--	--	--	--	GRC	Carson Water Co.	B-28-17 23DDD
--	--	--	--	Alluv	USGS	--	B-28-17 31CCC
--	--	--	--	--	R	--	
--	--	--	--	--	USGS	--	
--	--	--	--	--	USGS	--	
--	--	--	--	Br	DR	BLM (White Hills Well)	B-28-19 01BB
NO	--	--	--	--	GRC	Controlled by Sloan	B-28-19 16DAC
--	.5	9/11/80	--	Alluv	USGS, R	BLM (Cyclopic Well)	B-28-19 25ABB
NO	22	--	17	--	GRC, OWN	Controlled by Sloan	B-28-20 13BAA
--	22	--	400	--	ADWR	Goldfield Corp.	B-28-21 03ABB
--	--	--	--	--	ADWR	Goldfield Corp.	B-28-21 03ABC
YES	100	--	--	Alluv	GRC, DR, OWN	BLM (Wheat Well)	B-28-21 20AAC
YES	29	1982	--	Alluv	GRC, OTH	Tanner Co.	B-28-21 26BBD
--	--	--	--	--	USGS, R	--	B-29-15 08ADD
--	--	--	--	DCs	USGS, R, DR	BLM (Grapevine Canyon Well)	B-29-15 08BDB
--	--	--	--	--	USGS, R	--	B-29-15 18ABA
--	335	11/15/76	--	--	USGS, R	--	B-29-17 03DDB
--	--	--	--	--	USGS, R	--	B-29-17 23CCB
YES	40	4/23/82	--	Br	GRC	Lake Mead Land & Water	
--	25	10/16/63	10	--	DR	--	
YES	2.6	4/23/82	--	--	GRC	--	B-29-17 36DDA
--	--	--	--	--	USGS, R	--	B-29-18 01CCC
--	--	--	--	--	R	--	
NO	7.5	--	0	--	GRC, OWN	Sloan	B-29-19 20CCD
YES	22	--	--	Alluv	GRC, OWN	Sloan	B-29-21 35CCC

APPENDIX B

APPENDIX B
Water Quality Data Tables

Table B-1: WELLS--CONCENTRATIONS OF MAJOR IONS

Samples Collected by GRC, 1982

SITE NUMBER	DATE SAMPLED	DEPTH SAMPLED (feet)	TEMP (°C)	SPECIFIC CONDUCTANCE (umhos) FIELD	SPECIFIC CONDUCTANCE (umhos) LAB	pH FIELD	pH LAB	POTASSIUM (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	SODIUM (mg/l)	IRON (ug/l)
B-21-17 10DDC1	5/ 7/82	80	22.0	570	560	7.6	7.8	2.7	56	31	17	<9
B-21-17 23BBB1	5/ 7/82	290	24.2	525	520	7.7	8.1	2.7	50	21	25	<9
B-21-17 23BDB1	5/10/82	--	23.6	615	620	7.5	7.6	4.3	60	25	24	10
B-22-13 9ABC1	4/14/82	--	25.8	345	358	8.1	8.3	2.8	22	16	25	<9
B-22-13 13AAD1	4/14/82	--	23.1	1865	1660	7.3	7.4	2.8	155	82	70	18
B-22-17 7CDD1	3/15/82	175	22.1	1830	1900	7.2	7.4	6.5	160	70	140	1100
B-22-17 7CDD2	3/15/82	70	20.0	2400	2460	7.4	7.5	6.7	170	110	230	22
B-23-13 22BBA1	4/15/82	25	16.5	745	805	7.4	7.7	2.2	70	42	43	<9
B-23-13 29ABA1	4/14/82	30	20.9	820	789	7.2	8.2	42	72	1.8	64	<9
B-23-15 4DDD1	5/ 6/82	585	29.2	490	470	7.8	8.0	4.5	24	26	38	<9
B-23-18 6AAD1	5/ 5/82	75	19.8	4975	5200	6.8	7.0	17	530	280	250	160
B-23-18 15BAA1	5/ 5/82	55	18.2	3200	2900	9.0	7.8	8.4	240	110	280	60
B-23-18 35DCC1	3/16/82	44	18.5	5670	3200	7.7	7.2	6.3	470	120	120	11,000
B-23-20 11CAA1	5/ 3/82	--	31.4	3530	356	8.1	8.1	1.3	28	8.4	34	<5
B-24-14 28CAD1	4/15/82	542	25.3	630	626	7.7	8.1	4.6	54	29	38	<9
B-24-21 10DDB1	5/ 3/82	30	26.4	1200	860	7.5	8.2	2.8	80	24	75	<9
B-25-14 15BAB1	4/22/82	--	12.1	2220	1920	9.2	8.1	13	51	85	270	18
B-25-19 1BAB1	4/21/82	412	29.2	450	437	7.9	8.2	7.7	31	19	23	<9
B-25-19 1BDA1	3/31/82	515	20.4	487	455	8.5	8.4	8.0	39	21	21	19
B-25-19 3CCC1	3/31/82	700	30.3	434	421	8.8	8.2	7.9	20	11	49	<9
B-25-19 11CBD1	3/31/82	680	21.4	481	466	8.8	8.5	13	25	20	37	11
B-25-19 30AAA1	4/ 4/82	800	26.4	424	410	8.1	8.4	3.5	35	12	29	<9
B-25-20 15DAD1	3/31/82	720	17.1	347	375	8.4	8.3	7.3	31	10	26	150
B-25-21 3ABA1	4/ 3/82	--	15.9	794	811	6.1	8.4	5.8	99	27	43	7
B-25-21 27ABA1	3/27/82	38	16.5	1405	1480	8.5	7.9	4.7	142	29	150	77
B-25-21 35DAB1	3/27/82	170	15.9	920	950	8.9	8.3	2.1	66	39	61	<9
B-26-14 16BAB1	4/12/82	--	11.0	740	696	7.7	8.1	2.1	78	50	13	<9
B-26-14 30CCB1	4/17/82	40	22.5	2480	1860	7.6	8.0	5.7	79	51	290	60
B-26-14 36DAC1	4/12/82	13	14.8	668	655	7.4	8.1	1.6	91	31	17	<9
B-26-15 23DAC1	4/17/82	--	23.1	1890	1560	7.7	7.9	7.4	97	72	160	<9
B-26-19 02BAD1	4/21/82	33	19.2	1700	1290	7.5	8.2	2.6	110	80	51	<9
B-26-19 3ACD1	4/21/82	76	19.2	665	680	7.4	7.4	4.1	56	33	35	48
B-26-19 25AAC1	5/ 4/82	140	20.3	1415	1040	7.8	8.2	3.5	84	50	49	<9
B-26-19 35DDA1	4/21/82	330	28.2	390	375	8.1	8.3	3.0	18	10	44	<9
B-26-19 36CCB1	4/21/82	348	27.1	450	440	8.1	8.2	5.2	31	16	31	22

mg/l = milligrams per liter = 10^{-3} grams per liter
ug/l = micrograms per liter = 10^{-6} grams per liter

Table B-1: WELLS--CONCENTRATIONS OF MAJOR IONS

Samples Collected by GRC, 1982

SITE NUMBER	BORON (ug/l)	SILICA (mg/l)	NITROGEN (nitrate and nitrite as N) (mg/l)	PHOSPHORUS (mg/l)	CHLORIDE (mg/l)	FLUORIDE (mg/l)	SULFATE (mg/l)	HARDNESS CARBONATE (mg/l)	HARDNESS NON-CARBONATE (mg/l)	TOTAL DISSOLVED SOLIDS (mg/l)
B-21-17 10DDC1	70	70	4.3	0.03	22	0.4	28	270	37	367
B-21-17 23BBB1	80	50	3.4	0.02	29	0.5	22	210	11	328
B-21-17 23BDB1	100	50	4.1	0.02	57	0.6	34	200	53	403
B-22-13 09ABC1	70	32	3.2	<0.01	21	0.5	14	120	1	211
B-22-13 13AAD1	150	28	1.1	<0.01	330	0.5	130	720	410	1060
B-22-17 07CDD1	140	31	<0.10	<0.01	200	1.2	480	690	450	1300
B-22-17 07CDD2	280	47	0.20	0.01	210	2.3	680	880	480	1760
B-23-13 22BBA1	170	48	0.21	<0.01	56	0.6	43	350	28	489
B-23-13 29ABA1	180	48	--	--	64	0.7	66	350	53	509
B-23-15 04DDD1	170	37	2.0	0.01	27	5.6	34	170	0.0	291
B-23-18 06AAD1	160	3.8	2.6	<0.01	1300	1.4	900	44	2400	3200
B-23-18 15BAA1	120	<1.9	0.13	<0.01	330	0.7	1200	31	1000	2320
B-23-18 35DCC1	160	39	<0.10	<0.01	70	1.2	1600	1700	1500	2790
B-23-20 11CAA1	70	35	2.6	0.02	36	0.3	16	100	0.00	229
B-24-14 28CAD1	130	36	3.8	<0.01	63	0.6	39	250	44	288
B-24-21 10DDB1	260	30	3.8	<0.01	72	0.8	160	210	89	559
B-25-14 15BAB1	630	41	--	--	260	2.9	310	480	110	1200
B-25-19 01BAB1	80	58	--	--	35	0.7	23	140	16	290
B-25-19 01BDA1	90	45	--	--	47	0.7	31	180	64	315
B-25-19 03CCC1	200	63	--	--	23	0.7	21	95	0	296
B-25-19 11CBD1	150	36	--	--	58	0.9	22	140	0.0	283
B-25-19 30AAA1	130	30	--	--	46	0.6	28	140	27	256
B-25-20 15DAD1	80	44	--	--	26	0.7	17	120	0	328
B-25-21 3ABA1	100	30	--	--	23	0.8	98	360	48	542
B-25-21 27ABA1	490	35	--	--	71	3.0	150	470	330	1140
B-25-21 35DAB1	290	30	--	--	110	2.4	68	200	130	572
B-26-14 16BAB1	70	14	--	--	19	0.2	7.0	400	21	429
B-26-14 30CCB1	400	23	--	<0.02	200	5.7	390	410	47	1250
B-26-14 36DAC1	60	48	--	--	32	0.3	19	360	45	448
B-26-15 23DAC1	380	26	2.0	<0.01	110	2.7	430	540	250	1150
B-26-19 02BAD1	300	80	--	--	120	1.4	86	600	210	875
B-26-19 03ACD1	140	29	--	--	50	1.3	7	280	0	377
B-26-19 25AAC1	90	60	--	--	200	0.5	52	190	230	682
B-26-19 35DDA1	100	42	--	--	23	0.5	18	120	0	251
B-26-19 36CCB1	110	48	--	--	33	0.5	30	137	3	288

Table B-1: WELLS--CONCENTRATIONS OF MAJOR IONS

Samples Collected by GRC, 1982

SITE NUMBER	DATE SAMPLED	DEPTH SAMPLED (feet)	TEMP (°C)	SPECIFIC CONDUCTANCE (umhos) FIELD	SPECIFIC CONDUCTANCE (umhos) LAB	pH FIELD	pH LAB	POTASSIUM (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	SODIUM (mg/l)	IRON (ug/l)
B-26-21 26CCB1	4/ 3/82	surf*	14.3	110	143	9.2	8.9	3.2	24	3.4	6.8	10
B-27-18 07CBD2	4/24/82	55	19.2	1500	1190	7.7	8.1	12	63	61	84	<9
B-27-19 11DDA1	3/20/82	53	19.5	1310	820	7.7	7.8	2.3	56	54	43	4
B-27-19 12ACC1	4/24/82	50	19.2	760	665	7.9	8.2	6.7	40	51	26	21
B-27-19 16BBB1	3/21/82	690	22.0	993	520	8.1	8.2	4.5	17	27	50	<9
B-27-19 35BAD1	4/21/82	62	19.2	1510	1180	7.4	8.4	4.5	70	66	76	120
B-27-20 14ADC1	3/21/82	600	24.7	1252	640	7.9	7.9	4.7	34	23	69	12
B-27-21 24BDC1	3/24/82	480	29.7	456	495	8.1	8.2	3.6	27	11	53	10
B-27-21 25BAA1	3/30/82	464	19.8	434	431	8.8	8.3	4.1	23	9.7	51	10
B-27-21 25DDC1	4/ 2/82	380	27.7	439	453	8.8	8.5	4.4	18	9.3	59	10
B-27-21 29CBA1	4/ 2/82	77	18.7	3943	3850	8.8	8.3	35	640	210	98	30
B-28-15 16BBB1	4/11/82	--	13.7	737	705	8.0	8.3	2.3	96	35	16	<9
B-28-21 20AAC1	3/23/82	365	24.8	564	582	8.5	8.6	3.7	20	8.4	87	<5
B-28-21 26BBD1	3/24/82	235	26.4	578	605	8.1	7.6	4.0	42	17	49	10
B-29-17 23CCA1	4/23/82	950	25.8	395	390	8.0	8.1	4.4	14	18	42	<9
B-29-17 36DDA1	4/23/82	--	17.6	715	690	7.4	7.7	4.2	83	20	40	<9
B-29-21 35CCC1	3/19/82	--	11.5	1890	1020	8.9	8.4	7.3	52	12	130	6

* surf = ground surface

Table B-1: WELLS--CONCENTRATIONS OF MAJOR IONS

Samples Collected by GRC, 1982

SITE NUMBER	BORON (ug/l)	SILICA (mg/l)	NITROGEN (nitrate and nitrite as N) (mg/l)	PHOSPHORUS (mg/l)	CHLORIDE (mg/l)	FLUORIDE (mg/l)	SULFATE (mg/l)	HARDNESS CARBONATE (mg/l)	HARDNESS NON-CARBONATE (mg/l)	TOTAL DISSOLVED SOLIDS (mg/l)
B-26-21 26CCB1	50	3.1	--	--	2.6	0.2	5.0	74	2.0	110
B-27-19 07CBD1	320	41	--	--	200	3.9	87	210	200	752
B-27-19 11DDA1	170	78	--	--	45	0.5	42	360	12	514
B-27-19 12ACC1	130	68	--	--	39	2.2	27	280	30	423
B-27-19 16BBB1	170	18	--	--	32	1.5	45	150	0	296
B-27-19 35BAD1	370	59	--	--	100	1.5	79	390	57	739
B-27-20 14ADC1	230	31	--	--	49	1.9	35	180	0	385
B-27-21 24BDC1	100	26	--	--	40	1.0	63	110	3.0	298
B-27-21 25BAA1	100	28	--	--	35	1.2	43	97	0.0	272
B-27-21 25DDC1	100	29	--	--	36	1.1	41	83	0.0	278
B-27-21 29CBA1	300	10	--	--	34	1.1	2400	2500	2200	3930
B-28-15 16BBB1	20	28	--	--	29	<0.1	25	380	94	461
B-28-21 20AAC1	300	20	--	--	38	1.8	100	85	0.0	364
B-28-21 26BBD1	150	26	--	--	25	0.8	92	170	55	379
B-29-17 23CCA1	210	24	--	--	14	1.1	11	160	0	229
B-29-17 36DDA1	100	22	--	--	56	3.0	54	290	170	383
B-29-21 35CCC1	380	16	--	--	75	1.1	290	180	110	647

Table B-2: WELLS--CONCENTRATIONS OF HEAVY METAL IONS

Samples Collected by GRC, 1982

SITE NUMBER	DATE SAMPLED	DEPTH SAMPLED (feet)	TEMP (°C)	ALUMINUM (ug/l)	ANTIMONY (ug/l)	ARSENIC (ug/l)	BARIUM (ug/l)	BERYLLIUM (ug/l)	BISMUTH (ug/l)	CADMIUM (ug/l)	CHROMIUM (ug/l)	COBALT (ug/l)	COPPER (ug/l)
B-21-17 10DDC1	5/ 7/82	80	22.0	<50	<30	2	10	<1	<1000	<1	<50	<5	<10
B-21-17 23BBB1	5/ 7/82	290	24.2	<50	<30	4	30	<1	<1000	<1	<50	<5	<10
B-21-17 23BDB1	5/10/82	--	23.6	<50	<30	3	30	<1	<1000	1	<50	<5	<10
B-22-17 7CDD1	3/15/82	175	22.1	--	--	--	24	<1	--	<1	--	<3	<10
B-22-17 7CDD2	3/15/82	70	20.0	--	--	--	34	4	--	5	--	<9	<30
B-23-18 6AAD1	5/ 5/82	75	19.8	<50	50	<1	70	<1	<1000	3	<50	<5	<10
B-23-18 15BAA1	5/ 5/82	55	18.2	<50	<30	<1	30	<1	<1000	<1	<50	<5	<10
B-23-18 35DCC1	3/16/82	44	18.5	--	--	--	26	4	--	5	--	<9	<30
B-23-20 11CAA1	5/ 3/82	--	31.4	<50	<30	10	30	<1	<1000	1	<50	<5	<10
B-24-21 10DDB1	5/ 3/82	30	26.4	<50	<30	<1	30	<1	<1000	<1	<50	<5	<10
B-25-21 3ABA1	4/ 3/82	--	15.9	<50	<30	1	70	<1	<1000	<1	<50	<5	<10
B-25-21 27ABA1	3/27/82	38	16.5	<50	<30	54	100	<1	<1000	<1	<50	<5	10
B-25-21 35DAB1	3/27/82	170	15.9	<50	<30	7	70	<1	<1000	<1	<50	<5	<10
B-26-21 26CCB1	4/ 3/82	surf.	14.3	<50	<30	5	100	<1	<1000	<1	<50	<5	10
B-27-21 24BDC1	3/24/82	480	29.7	<50	<30	12	70	<1	<1000	<1	<50	<5	<10
B-27-21 25BAA1	3/30/82	464	19.8	<50	<30	10	70	<1	<1000	<1	<50	<5	<10
B-27-21 25DDC1	4/ 2/82	380	27.7	<50	<30	8	30	<1	<1000	<1	<50	<5	<10
B-27-21 29CBA1	4/ 2/82	77	18.7	70	50	2000	10	<1	<1000	3	<50	<5	10
B-28-21 20AAC1	3/23/82	365	24.8	<50	<30	21	50	<1	<1000	<1	<50	<5	<10
B-28-21 26BBD1	3/24/82	235	26.4	<50	<30	7	70	<1	<1000	<1	<50	<5	<10

ug/l = micrograms per liter = 10^{-6} grams per liter

Table B-2: WELLS--CONCENTRATIONS OF HEAVY METAL IONS

Samples Collected by GRC, 1982

SITE NUMBER	GALLIUM (ug/l)	GERMANIUM (ug/l)	LEAD (ug/l)	LITHIUM (ug/l)	MANGANESE (ug/l)	MOLYBDENUM (ug/l)	NICKEL (ug/l)	SILVER (ug/l)	STRONTIUM (ug/l)	TIN (ug/l)	TITANIUM (ug/l)	VANADIUM (ug/l)	ZINC (ug/l)	ZIRCONIUM (ug/l)
B-21-17 10DCC1	<30	70	<30	7	10	<10	<50	<10	500	100	<5	<10	100	<5
B-21-17 23BBB1	<30	50	<30	7	1	<10	<50	<10	500	100	<5	10	500	<5
B-21-17 23BDB1	<30	70	<30	10	5	10	<50	<10	500	100	<5	10	100	<5
B-22-17 7CDD1	--	--	<10	65	140	<10	--	--	1500	--	--	<6.0	800	--
B-22-17 07CDD2	--	--	60	50	21	<30	--	--	1100	--	--	11	110	--
B-23-18 06AAD1	50	500	<30	100	1000	10	<50	<10	7000	1000	10	<10	7000	<5
B-23-18 15BAA1	<30	300	<30	30	700	<10	<50	<10	1000	700	7	<10	30	<5
B-23-18 35DCC1	--	--	50	59	150	220	--	--	1600	--	--	<9	110	--
B-23-20 11CAA1	<30	<30	<30	30	1	10	<50	<10	300	70	<5	10	30	<5
B-24-21 10DDB1	<30	70	<30	30	7	10	<50	<10	1000	100	<5	<10	100	<5
B-25-21 03ABA1	30	100	<30	10	1	10	<50	<10	500	100	<5	<10	30	<5
B-25-21 27ABA1	<30	70	<30	30	7	100	<50	<10	700	100	<5	100	30	<5
B-25-21 35DAB1	<30	<30	<30	30	7	30	<50	<10	1000	300	<5	10	300	5
B-26-21 26CCB1	<30	<30	<30	<5	1	<10	<50	<10	100	<50	<5	<10	10	<5
B-27-21 24BDC1	<30	30	<30	50	<1	10	<50	<10	100	100	<5	10	10	<5
B-27-21 25BAA1	<30	30	<30	50	3	10	<50	<10	300	100	<5	10	50	<5
B-27-21 25DDC1	<30	30	<30	50	7	10	<50	<10	100	50	<5	10	30	<5
B-27-21 29CBA1	100	500	50	100	10	50	<50	<10	1000	1000	10	10	50	<5
B-28-21 20AAC1	<30	30	<30	50	3	50	<50	<10	1000	100	<5	10	300	<5
B-28-21 26BBD1	<30	70	<30	50	3	10	<50	<10	1000	100	<5	10	70	<5

Table B-3: WELLS--CONCENTRATIONS OF MAJOR IONS

Samples Collected by Remick, 1981

SITE NUMBER	SODIUM (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	CHLORIDE (mg/l)	BICARBONATE (mg/l)	SULFATE (mg/l)	DISSOLVED SOLIDS (Calculated as sum of constituents) (mg/l)
B-22-13 09ABC	28	26	18	21	153	10	218*
B-22-16 15CCC	29	48	2	32	183	24	240
B-22-16 27DDD	18	44	2	18	153	19	210
B-22-16 28BAD	37	94	11	74	153	77	330
B-22-16 33BCD	30	44	7	25	177	10	210
B-23-13 19DDA	53	36	15	32	183	29	--
B-23-13 29DBC	40	70	27	57	281	34	462*
B-23-16 07BDA	41	132	23	142	177	53	620*
B-23-17 35BDB	214	174	68	167	366	557	1099*
B-24-16 01DDD	51	26	28	92	159	24	328*
B-26-15 23DAC	129	60	41	103	195	259	--
B-26-18 01BDB	18	30	33	46	165	34	337*
B-26-18 03AAA1	32	22	21	35	177	38	289*
B-26-18 05DBB	53	12	10	25	165	34	234*
B-29-17 23CCB	41	18	18	14	189	14	238*

* determined quantitatively as residue on evaporation at 180 degrees Centigrade

mg/l = milligrams per liter = 10^{-3} grams per liter

Table B-4: WELLS--CONCENTRATIONS OF MAJOR IONS

Compiled by Gillespie, Bentley, and Kam, 1966

SITE NUMBER	DATE SAMPLED	DEPTH SAMPLED (Feet)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	SODIUM (mg/l)	IRON (mg/l)	BORON (mg/l)	NITRATE (mg/l)
B-21-17 01CAB1	09/11/63	503	48	31	12	--	--	9.0
B-21-17 03DC3	11/10/64	186	45	26	11	--	--	6.0
B-21-17 24CBC1	11/10/64	--	58	30	26	--	--	7.0
B-21-17 24CDA1	--/--/62	178	66	25	25	--	--	15
B-21-17 24CDB1	11/10/64	232	62	25	27	--	--	9.0
B-21-17 24CDD2	11/10/64	--	45	24	26	--	--	14
B-22-15 33DAD1	06/10/65	1,220	15	5	83	--	0.26	12
B-22-16 28DBB1	01/09/64	1,000	29	19	30	--	--	8.0
B-22-18 12CAA1	07/08/64	120	122	47	116	--	--	--
B-23-13 19CBB1	11/10/64	150	30	32	42	0.9	--	5.0
B-23-13 19DDA1	11/10/64	1,030	40	17	47	--	--	2.0
B-24-13 20CCD1	11/10/64	355	50	33	45	--	--	8.0
B-23-13 29DBC2	11/10/64	593	69	28	42	0.2	--	2.0
B-23-15 08DDD1	03/05/65	929	48	9	53	0.2	--	7.0
B-23-18 03ADB1	--/--/62	145	200	84	100	--	--	--
B-23-18 03CBB1	--/--/62	104	200	34	225	--	--	150
B-28-17 31CCC1	06/10/65	800	3.6	1.2	460	--	0.55	0.4

mg/l = milligrams per liter = 10^{-3} grams per liter

Table B-4: WELLS--CONCENTRATIONS OF MAJOR IONS

Compiled by Gillespie, Bentley, and Kam, 1966

SITE NUMBER	CHLORIDE (mg/l)	FLOURIDE (mg/l)	SULFATE (mg/l)	CARBONATE (mg/l)	BICARBONATE (mg/l)	HARDNESS AS CALCIUM CARBONATE (mg/l)	TOTAL DISSOLVED SOLIDS (mg/l)
B-21-17 01CAB1	6.0	0.4	12	0	180	250	358
B-21-17 03DC3	15	0.4	10	0	204	220	322
B-21-17 24CBC1	41	0.6	29	2	208	270	390
B-21-17 24CDA1	48	0.8	31	--	--	270	391
B-21-17 24CDB1	51	1.0	28	12	200	260	422
B-21-17 24CDD2	65	0.9	34	0	124	210	376
B-22-15 33DAD1	30	1.2	38	0	176	58	302
B-22-16 28DBB1	0.5	0.9	13	0	152	150	282
B-22-18 12CAA1	88	1.1	295	0	390	499	1,058
B-23-13 19CBB1	52	0.5	36	4	172	210	415
B-23-13 19DDA1	46	0.5	26	10	174	168	358
B-23-13 20CCD1	58	0.5	39	8	228	260	444
B-23-13 29DBC2	66	0.4	37	12	240	290	486
B-23-15 08DDD1	57	1.7	45	0	132	158	344
B-23-18 03ADB1	50	2.2	475	--	--	746	1,674
B-23-18 03CBB1	264	1.7	460	--	--	765	1,431
B-28-17 31CCC1	528	1.2	95	41	120	14	1,200

Table B-5: SPRINGS--CONCENTRATIONS OF MAJOR IONS

Samples Collected by GRC, 1982

SITE NUMBER	DATE SAMPLED	DEPTH * SAMPLED (feet)	TEMP (°C)	SPECIFIC CONDUCTANCE (umhos) FIELD	SPECIFIC CONDUCTANCE (umhos) LAB	pH FIELD	pH LAB	POTASSIUM (mg/l)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	SODIUM (mg/l)	IRON (ug/l)
B-21-17 2CCB1	5/ 7/82	surf	22.6	485	475	7.5	7.7	2.3	47	28	12	5
B-23-15 13CCB1	4/17/82	surf	18.7	1400	1080	7.3	7.7	3.9	108	41	65	2600
B-25-21 2CCB1	4/ 3/82	surf	15.9	1090	1000	7.3	8.0	2.3	142	33	56	7
B-25-21 23CCC1	3/27/82	surf	20.9	398	499	10.3	9.0	15	52	9.6	24	57
B-26-18 31BDB3	5/04/82	surf	20.9	440	425	7.9	7.9	6.1	40	18	18	<9
B-26-19 20ACD1	4/ 4/82	surf	23.1	510	481	7.8	8.4	1.8	32	19	44	<9
B-27-15 15AAC1	4/16/82	surf	15.4	690	668	8.0	8.2	1.2	56	52	16	<9
B-27-15 27BCA1	4/16/82	surf	15.4	1880	1510	8.3	8.2	9.7	135	88	110	<9
B-27-19 11ADB1	3/20/82	surf	20.0	1500	720	7.7	7.8	4.2	48	36	40	16
B-28-17 24BCC1	4/22/82	surf	17.0	2200	1850	8.3	8.1	9.5	99	91	200	<9
B-30-22 13ADA1	3/19/82	surf	19.2	1545	800	8.3	8.3	12	87	27	42	21

* surf = ground surface

mg/l = milligrams per liter = 10^{-3} grams per liter

ug/l = micrograms per liter = 10^{-6} grams per liter

Table B-5: SPRINGS--CONCENTRATIONS OF MAJOR IONS

Samples Collected by GRC, 1982

SITE NUMBER	BORON (ug/l)	SILICA (mg/l)	NITROGEN (nitrate and nitrite as N) (mg/l)	PHOSPHORUS (mg/l)	CHLORIDE (mg/l)	FLUORIDE (mg/l)	SULFATE (mg/l)	HARDNESS CARBONATE (mg/l)	HARDNESS NON-CARBONATE (mg/l)	TOTAL DISSOLVED SOLIDS (mg/l)
B-21-17 2CCB1	70	66	2.7	0.04	14	0.5	13	230	23	312
B-23-15 13CCB1	110	26	<0.10	<0.02	120	2.3	160	440	230	680
B-25-21 2CCB1	100	42	--	--	46	1.5	200	490	140	730
B-25-21 23CCC1	130	11	--	<0.01	43	0.3	19	150	19	326
B-26-18 31BDB3	70	51	--	--	32	0.5	26	170	34	290
B-26-19 20ACD1	100	45	--	--	37	0.5	35	160	18	319
B-27-15 15AAC1	90	13	1.2	<0.01	22	0.2	22	350	54	380
B-27-15 27BCA1	310	39	0.14	<0.01	96	4.1	420	700	390	1130
B-27-19 11ADB1	140	55	--	--	33	0.6	34	270	0.0	407
B-28-17 24BCC1	500	21	--	--	160	6.3	490	320	300	1290
B-30-22 13ADA1	250	51	--	--	34	0.6	77	330	48	498

Table B-6: SPRINGS--CONCENTRATIONS OF HEAVY METAL IONS

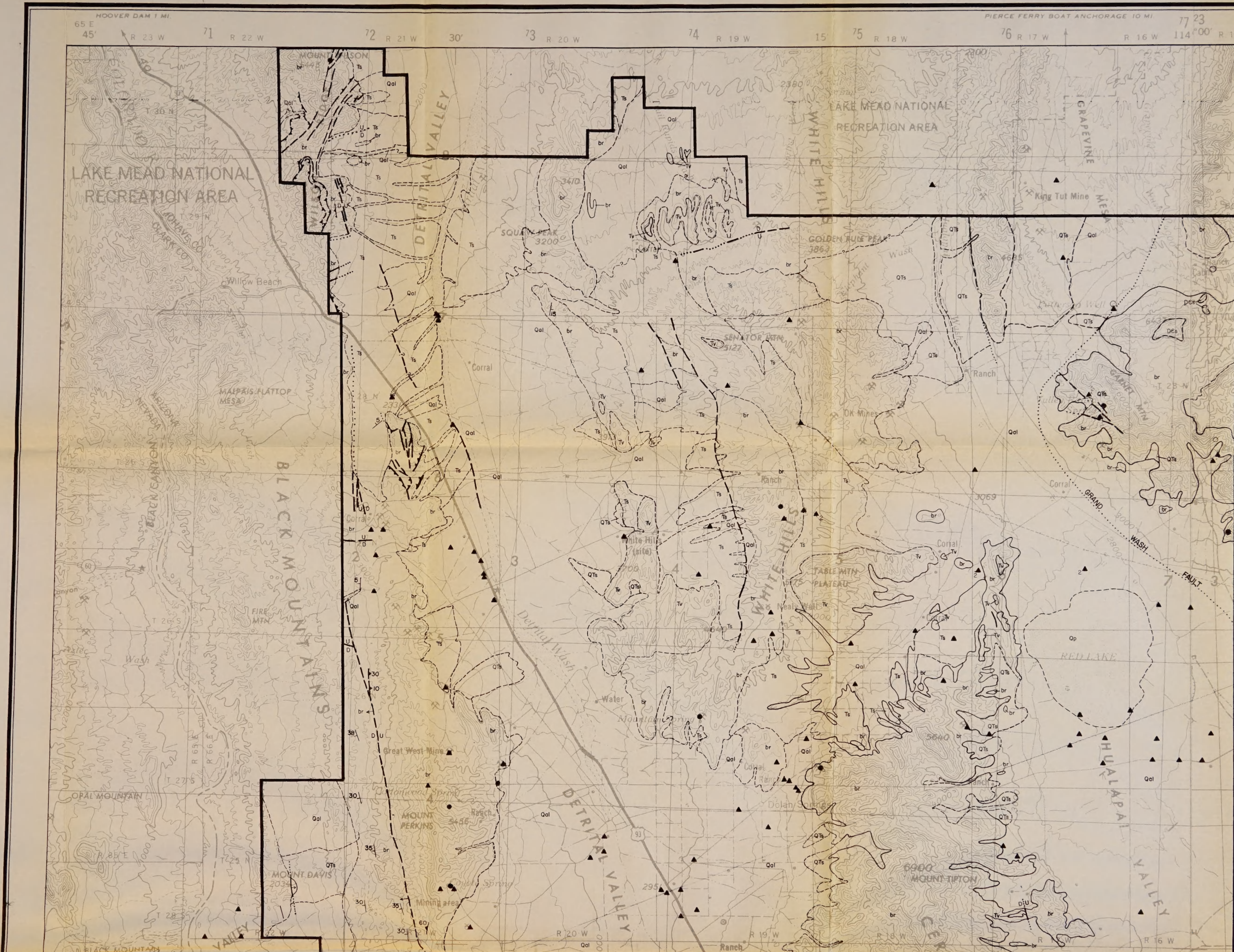
Samples Collected by GRC, 1982

SITE NUMBER	DATE SAMPLED	DEPTH* SAMPLED (feet)	TEMP (°C)	ALUMINUM (ug/l)	ANTIMONY (ug/l)	ARSENIC (ug/l)	BARIUM (ug/l)	BERYLLIUM (ug/l)	BISMUTH (ug/l)	CADMIUM (ug/l)	CHROMIUM (ug/l)	COBALT (ug/l)	COPPER (ug/l)
B-21-17 2CCB1	5/ 7/82	surf	22.6	<50	<30	2	10	<1	<1000	<1	<50	<5	<10
B-25-21 2CCB1	4/ 3/82	surf	15.9	<50	<30	1	70	<1	<1000	<1	<50	<5	<10
B-25-21 23CCC1	3/27/82	surf	20.9	<50	<30	3	100	<1	<1000	1	<50	<5	<10

SITE NUMBER	GALLIUM (ug/l)	GERMANIUM (ug/l)	LEAD (ug/l)	LITHIUM (ug/l)	MANGANESE (ug/l)	MOLYBDENUM (ug/l)	NICKEL (ug/l)	SILVER (ug/l)	STRONTIUM (ug/l)	TIN (ug/l)	TITANIUM (ug/l)	VANADIUM (ug/l)	ZINC (ug/l)	ZIRCONIUM (ug/l)
B-21-17 2CCB1	<30	70	<30	7	5	<10	<50	<10	300	100	<5	10	30	<5
B-25-21 02CCB1	30	100	<30	30	1	10	<50	<10	1000	100	<5	<10	30	<5
B-25-21 23CCC1	<30	<30	<30	7	100	30	<50	<10	300	<50	<5	<10	30	<5

* surf = ground surface

ug/l = micrograms per liter = 10^{-6} grams per liter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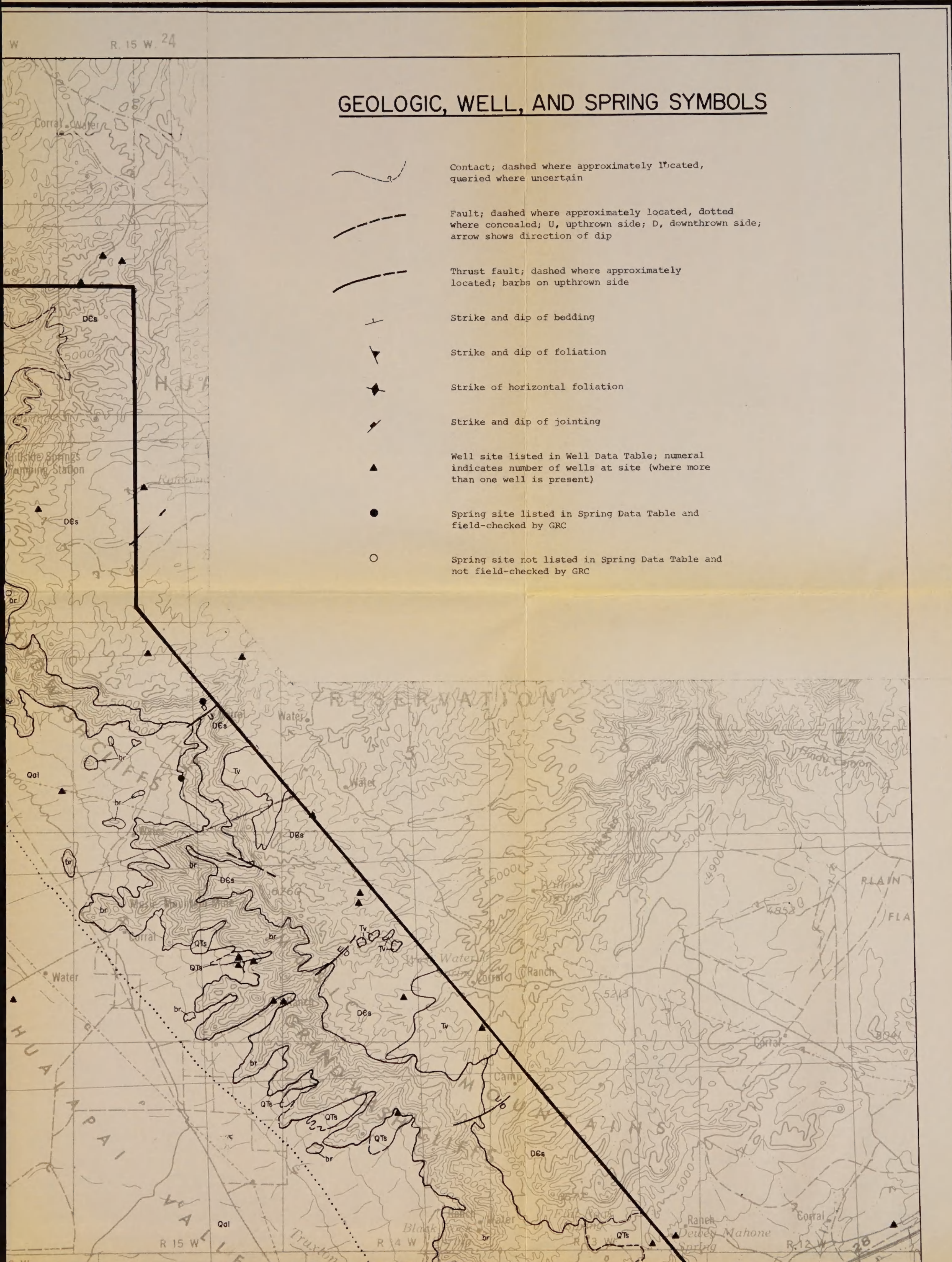
PIERCE FERRY BOAT ANCHORAGE 10 MI.
R 23 W
R 22 W
R 21 W
R 20 W
R 19 W
R 18 W
R 17 W
R 16 W
LAKE MEAD NATIONAL RECREATION AREA
LAKE MEAD NATIONAL RECREATION AREA
MOUNT WILSON
DETRITAL VALLEY
WHITE HILLS
GRAPEVINE MESA
King Tut Mine
SQUAW PEAK 3200
GOLDEN RULE PEAK 3863
SENATOR MTN 5127
Willow Beach
MOHAVE CO
CLARK CO
NEVADA
ARIZONA
MALPAIS FLATTOP MESA
BLACK MOUNTAINS
BLACK CANYON
Corral
OK Mines
Ranch
GARNET MTN
GRAND WASH FAULT
White Hills (site)
TABLE MTN PLATEAU
Neals Well
FIRE MTN
Detrital Wash
Water
RED LAKE
Great West Mine
MOUNT PERKINS
OPAL MOUNTAIN
MOUNT DAVIS
Mining area
Dolan Spring
MOUNT TIPTON
HUALAPAI VALLEY
DETRITAL VALLEY
VALLEY



GEOLOGIC, WELL, AND SPRING SYMBOLS

Contact; dashed where approximately located, queried where uncertain

Fault; dashed where approximately located, dotted where concealed; U, upthrown side; D, downthrown side; arrow shows direction of dip

Thrust fault; dashed where approximately located; barbs on upthrown side

Strike and dip of bedding

Strike and dip of foliation

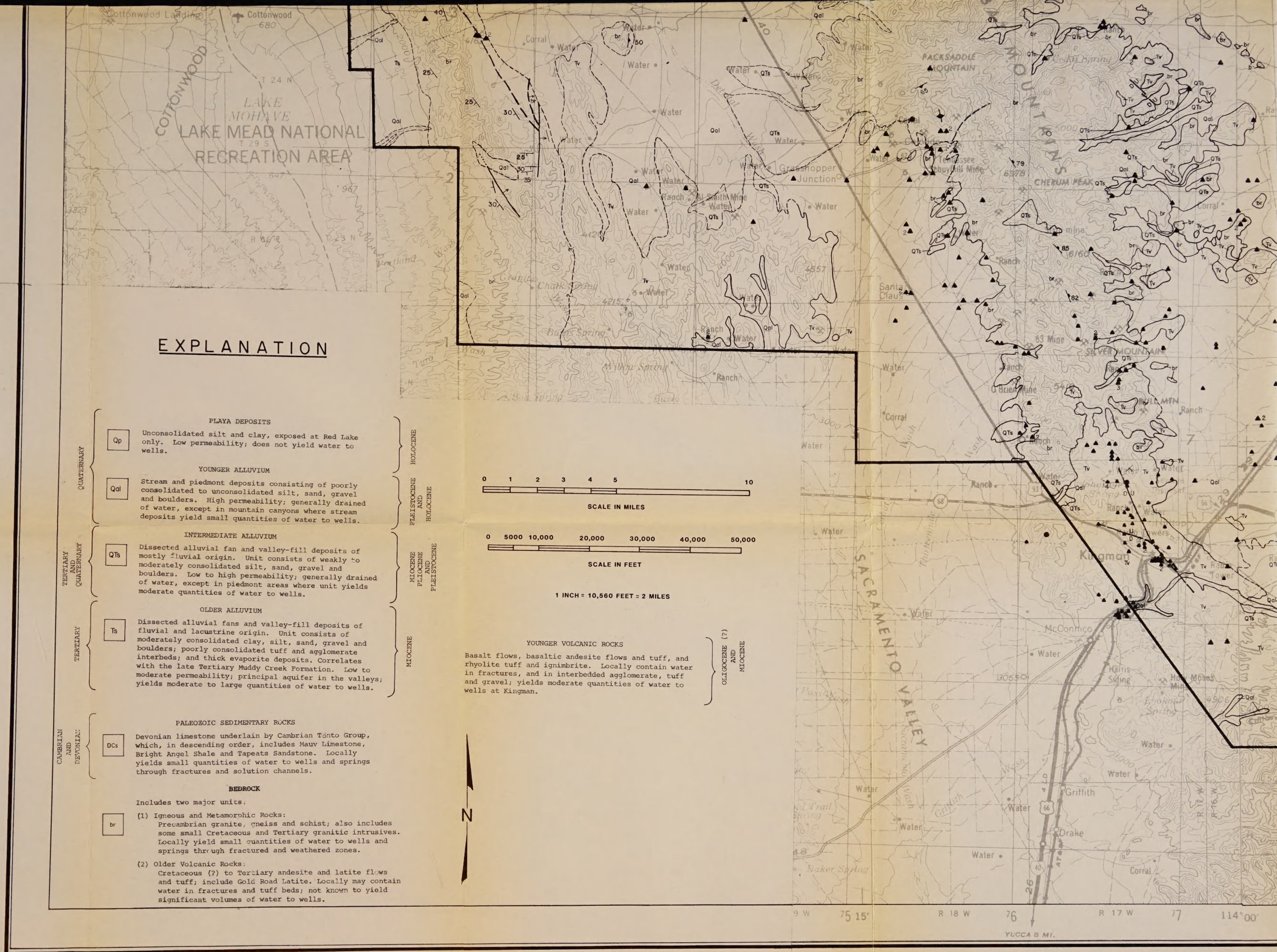
Strike of horizontal foliation

Strike and dip of jointing

Well site listed in Well Data Table; numeral indicates number of wells at site (where more than one well is present)

Spring site listed in Spring Data Table and field-checked by GRC

Spring site not listed in Spring Data Table and not field-checked by GRC



EXPLANATION

QUATERNARY

Qp — PLAYA DEPOSITS (HOLOCENE)

Unconsolidated silt and clay, exposed at Red Lake only. Low permeability; does not yield water to wells.

Qal — YOUNGER ALLUVIUM (PLEISTOCENE AND HOLOCENE)

Stream and piedmont deposits consisting of poorly consolidated to unconsolidated silt, sand, gravel and boulders. High permeability; generally drained of water, except in mountain canyons where stream deposits yield small quantities of water to wells.

TERTIARY AND QUATERNARY

QTs — INTERMEDIATE ALLUVIUM (MIOCENE PLIOCENE AND PLEISTOCENE)

Dissected alluvial fan and valley-fill deposits of mostly fluvial origin. Unit consists of weakly to moderately consolidated silt, sand, gravel and boulders. Low to high permeability; generally drained of water, except in piedmont areas where unit yields moderate quantities of water to wells.

TERTIARY

Ts — OLDER ALLUVIUM (MIOCENE)

Dissected alluvial fans and valley-fill deposits of fluvial and lacustrine origin. Unit consists of moderately consolidated clay, silt, sand, gravel and boulders; poorly consolidated tuff and agglomerate interbeds; and thick evaporite deposits. Correlates with the late Tertiary Muddy Creek Formation. Low to moderate permeability; principal aquifer in the valleys; yields moderate to large quantities of water to wells.

Tv — YOUNGER VOLCANIC ROCKS (OLIGOCENE (?) AND MIOCENE)

Basalt flows, basaltic andesite flows and tuff, and rhyolite tuff and ignimbrite. Locally contain water in fractures, and in interbedded agglomerate, tuff and gravel; yields moderate quantities of water to wells at Kingman.

CAMBRIAN AND DEVONIAN

DCs — PALEOZOIC SEDIMENTARY ROCKS

Devonian limestone underlain by Cambrian Tonto Group, which, in descending order, includes Mauv Limestone, Bright Angel Shale and Tapeats Sandstone. Locally yields small quantities of water to wells and springs through fractures and solution channels.

br — **BEDROCK**

Includes two major units.

(1) Igneous and Metamorphic Rocks:
Precambrian granite, gneiss and schist; also includes some small Cretaceous and Tertiary granitic intrusives. Locally yield small quantities of water to wells and springs through fractured and weathered zones.

(2) Older Volcanic Rocks:
Cretaceous (?) to Tertiary andesite and latite flows and tuff; include Gold Road Latite. Locally may contain water in fractures and tuff beds; not known to yield significant volumes of water to wells.

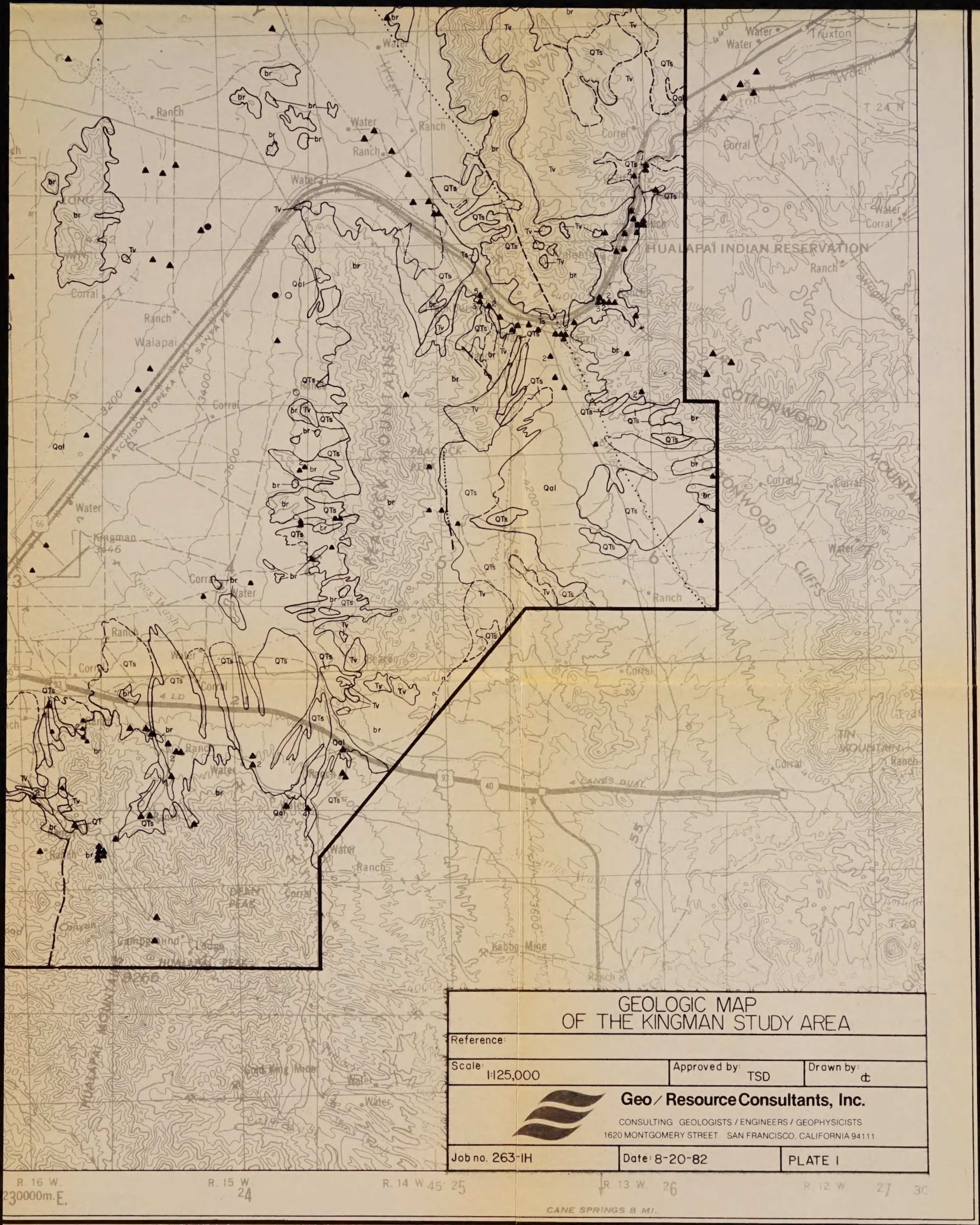
0 1 2 3 4 5 10

SCALE IN MILES

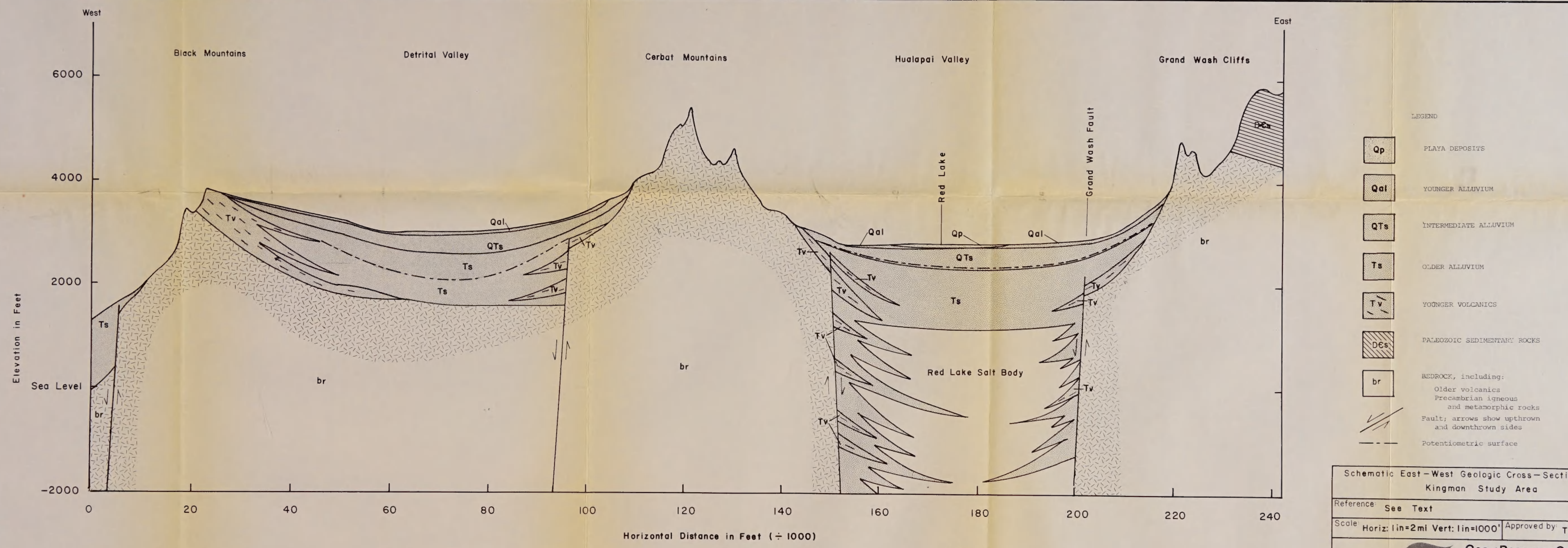
0 5000 10,000 20,000 30,000 40,000 50,000

SCALE IN FEET

1 INCH = 10,560 FEET = 2 MILES

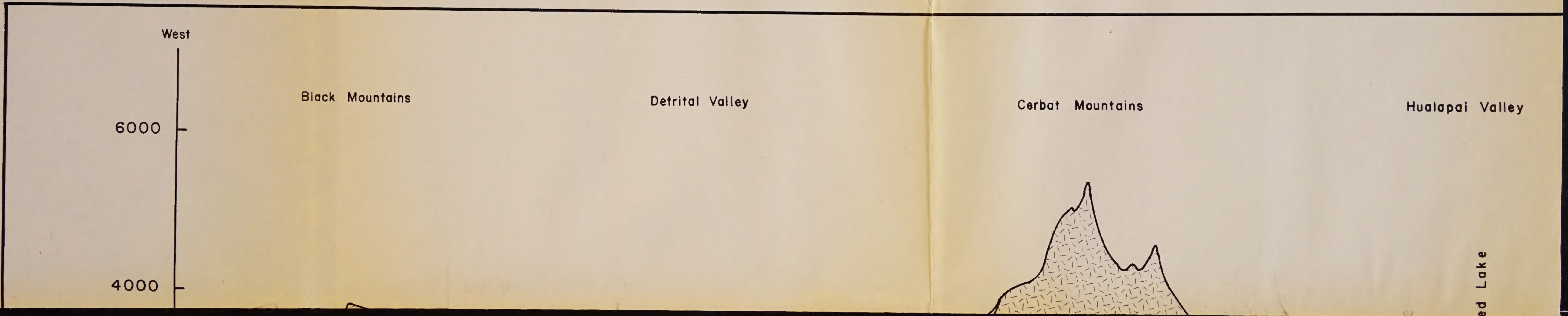


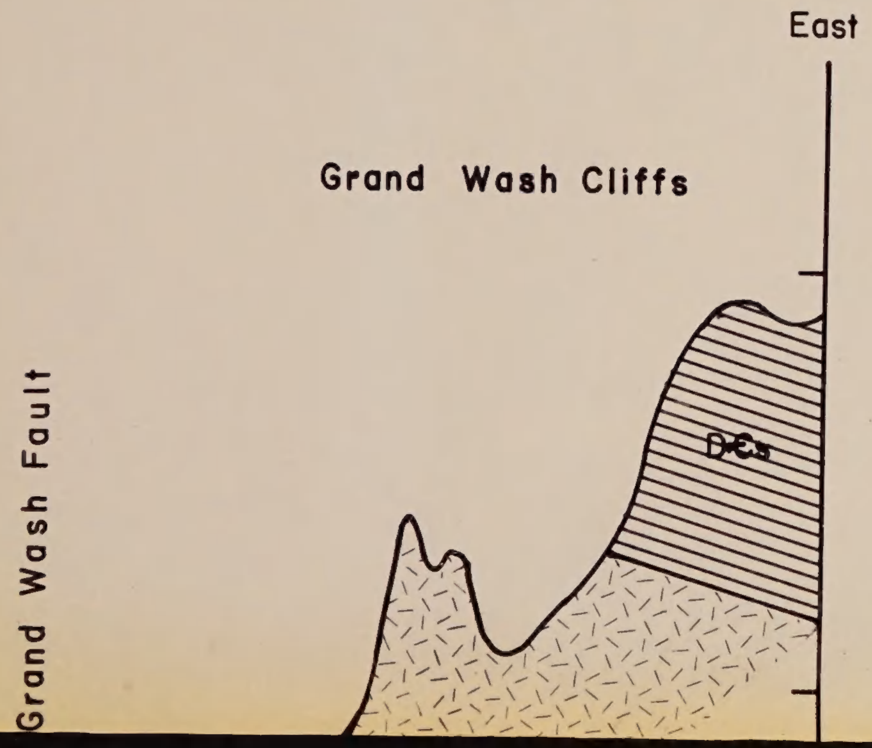
GEOLOGIC MAP
OF THE KINGMAN STUDY AREA
Reference:
Scale: 1:125,000
Approved by: TSD
Drawn by: dc
Geo / Resource Consultants, Inc.
CONSULTING GEOLOGISTS / ENGINEERS / GEOPHYSICISTS
1620 MONTGOMERY STREET SAN FRANCISCO, CALIFORNIA 94111
Job no. 263-IH
Date: 8-20-82
PLATE I
HUALAPAI INDIAN RESERVATION
ATCHISON TOPEKA AND SANTA FE
Kingman
Walapai
Truxton
COTTONWOOD
CLIFFS
TIN MOUNTAIN
Kabba Mine
Gold King Mine
QTs
Qal
Tv
br
R. 16 W.
R. 15 W.
R. 14 W.
R. 13 W.
R. 12 W.
230000m.E.
CANE SPRINGS 8 MI.



Schematic East-West Geologic Cross-Section Through The Kingman Study Area

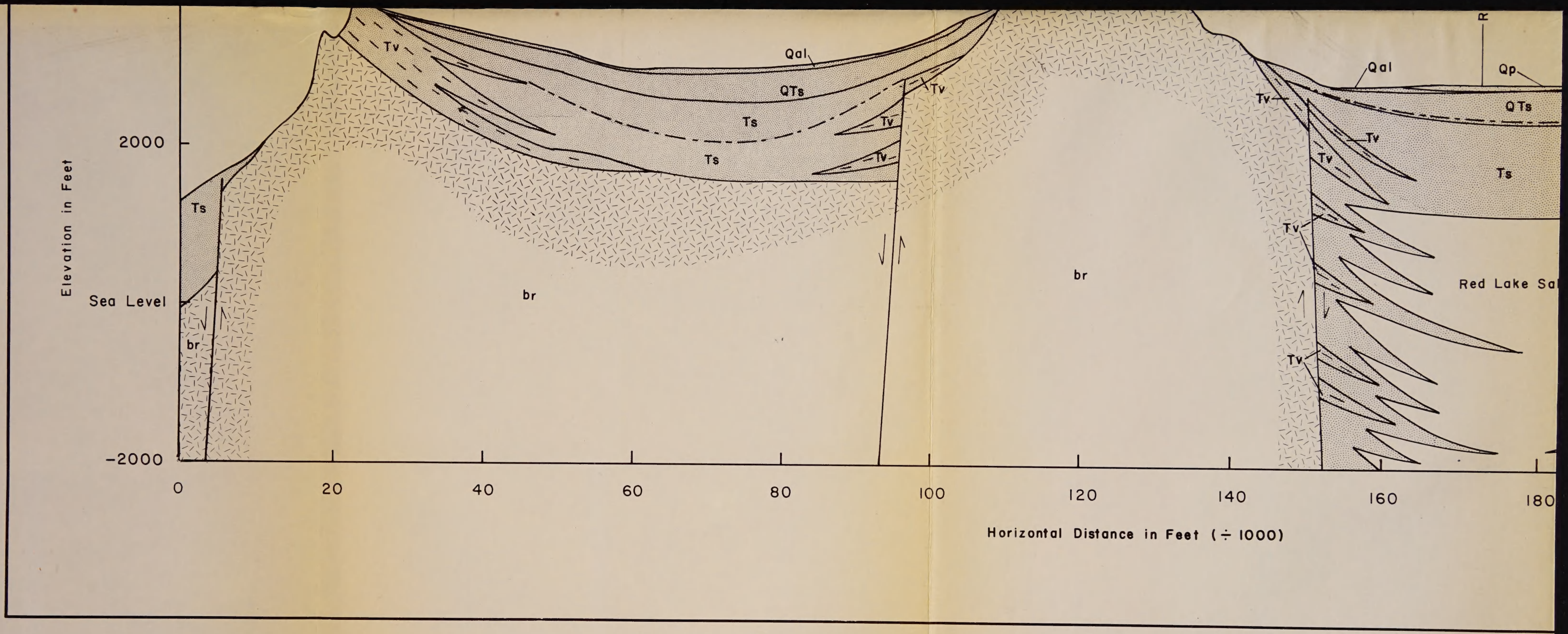
Reference: See Text		
Scale: Horiz: 1in=2mi Vert: 1in=1000'	Approved by: TSD	Drawn by: BCA
Geo/Resource Consultants, Inc. CONSULTING GEOLOGISTS / ENGINEERS / GEOPHYSICISTS 1620 MONTGOMERY STREET SAN FRANCISCO, CALIFORNIA 94111		
Job no. 263-1H	Date: 08/20/82	Plate 2


West
Black Mountains
Detrital Valley
Cerbat Mountains
Hualapai Valley
6000
4000

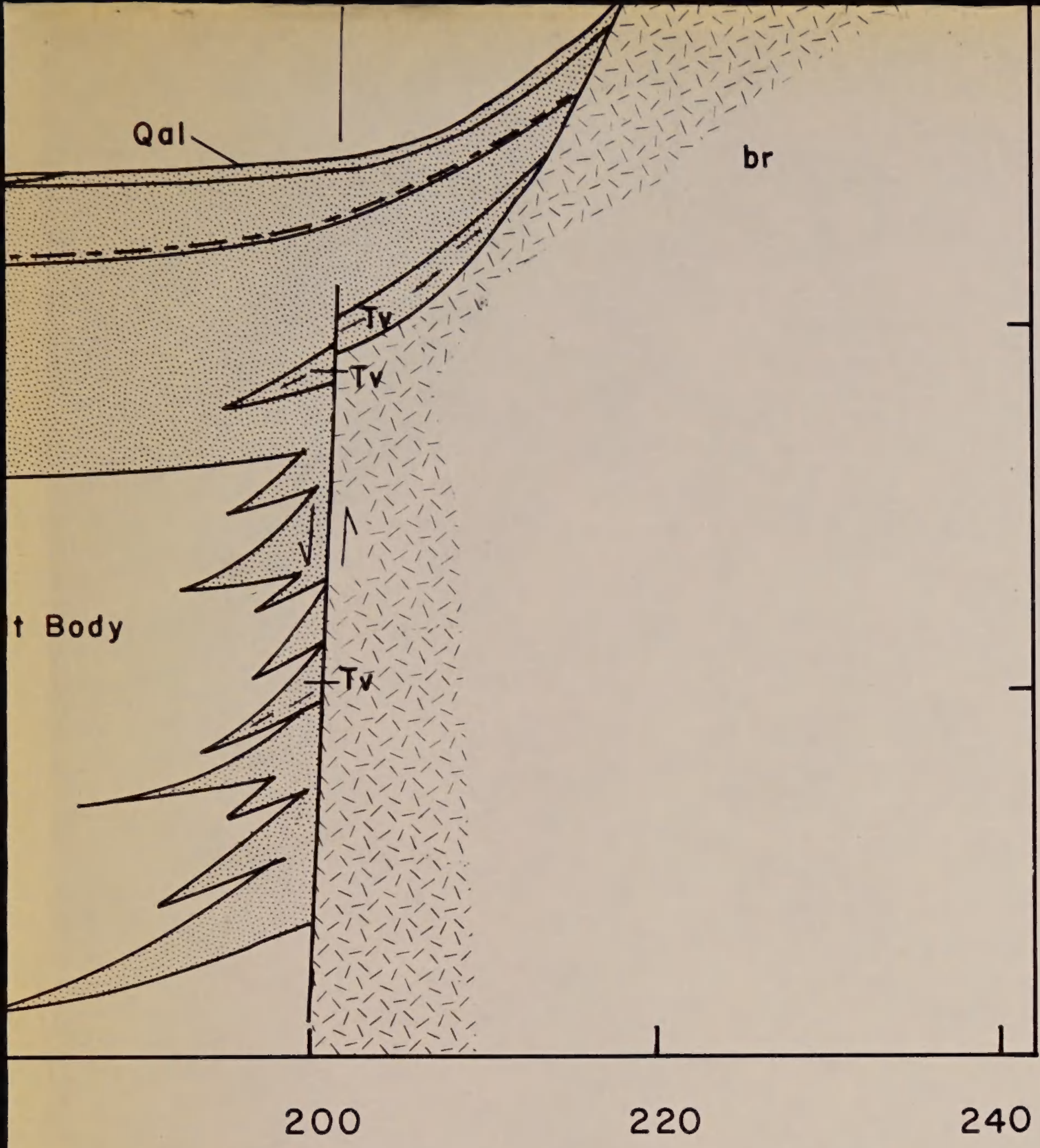


LEGEND

Qp	PLAYA DEPOSITS
Qal	YOUNGER ALLUVIUM

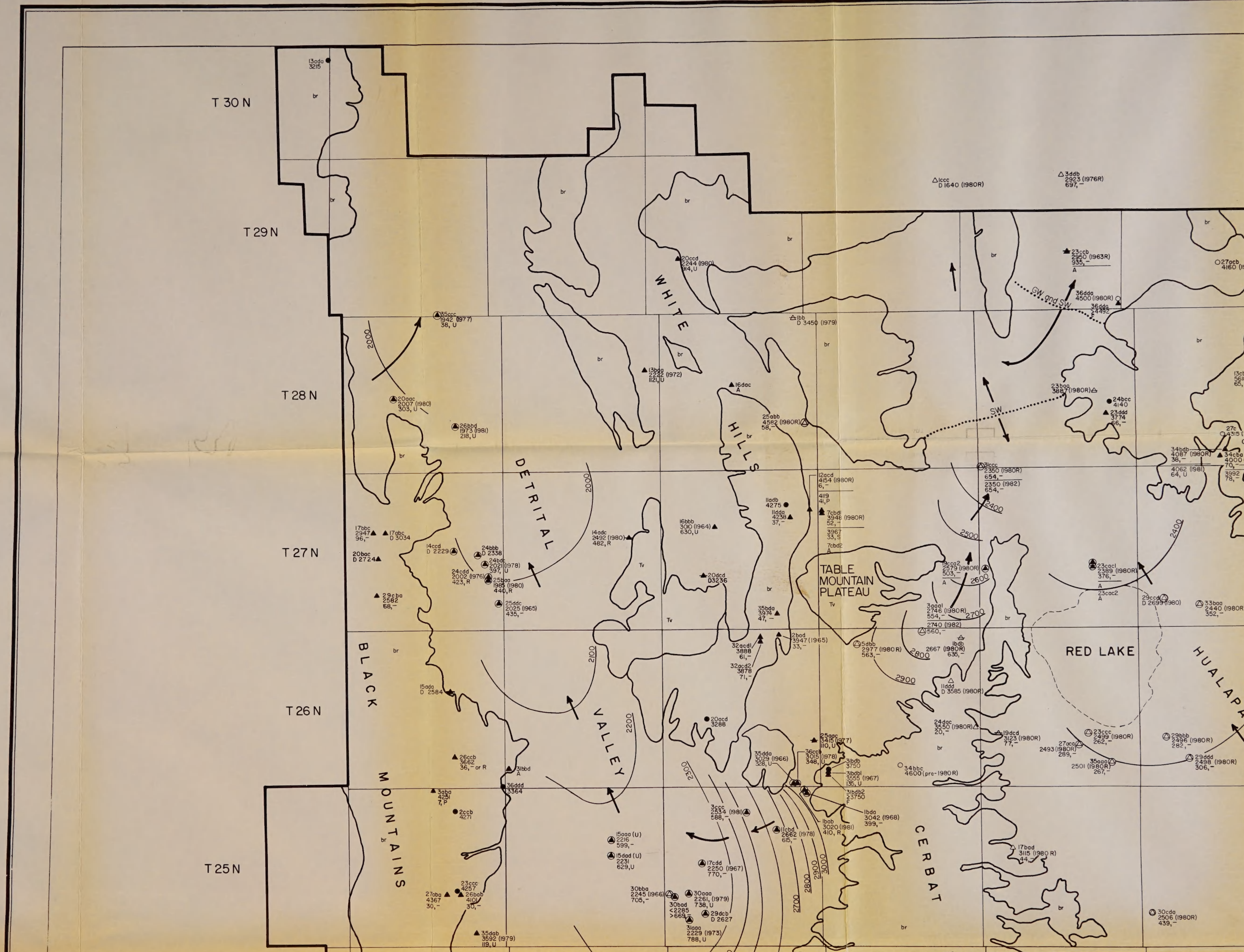


Elevation in Feet
2000
Sea Level
-2000
0
20
40
60
80
100
120
140
160
180
Horizontal Distance in Feet (÷ 1000)
Qal
QTs
Ts
Tv
br
Qp
R
Red Lake Sa



QTs	INTERMEDIATE ALLUVIUM
Ts	OLDER ALLUVIUM
Tv	YOUNGER VOLCANICS
DЄs	PALEOZOIC SEDIMENTARY ROCKS
br	BEDROCK, including: Older volcanics; Precambrian igneous and metamorphic rocks
	Fault; arrows show upthrown and downthrown sides
	Potentiometric surface

Schematic East – West Geologic Cross – Section Through The Kingman Study Area		
Reference: See Text		
Scale: Horiz: 1in=2mi Vert: 1in=1000'	Approved by: TSD	Drawn by: BCA
Geo / Resource Consultants, Inc. CONSULTING GEOLOGISTS / ENGINEERS / GEOPHYSICISTS 1620 MONTGOMERY STREET SAN FRANCISCO, CALIFORNIA 94111		
Job no. 263-1H	Date: 08/20/82	Plate 2



T 30 N
T 29 N
T 28 N
T 27 N
T 26 N
T 25 N
WHITE
HILLS
DETRITAL
VALLEY
BLACK
MOUNTAINS
TABLE MOUNTAIN PLATEAU
RED LAKE
HUALAPAI
CERBAT
GW and SW
SW

INTERPRETIVE HYDROGEOLOGIC SYMBOLS

2400 — Equipotential line in valley alluvium or in younger volcanics in Kingman area, with elevation in feet above msl.

Groundwater flow line in valley alluvium or in younger volcanics in Kingman area.

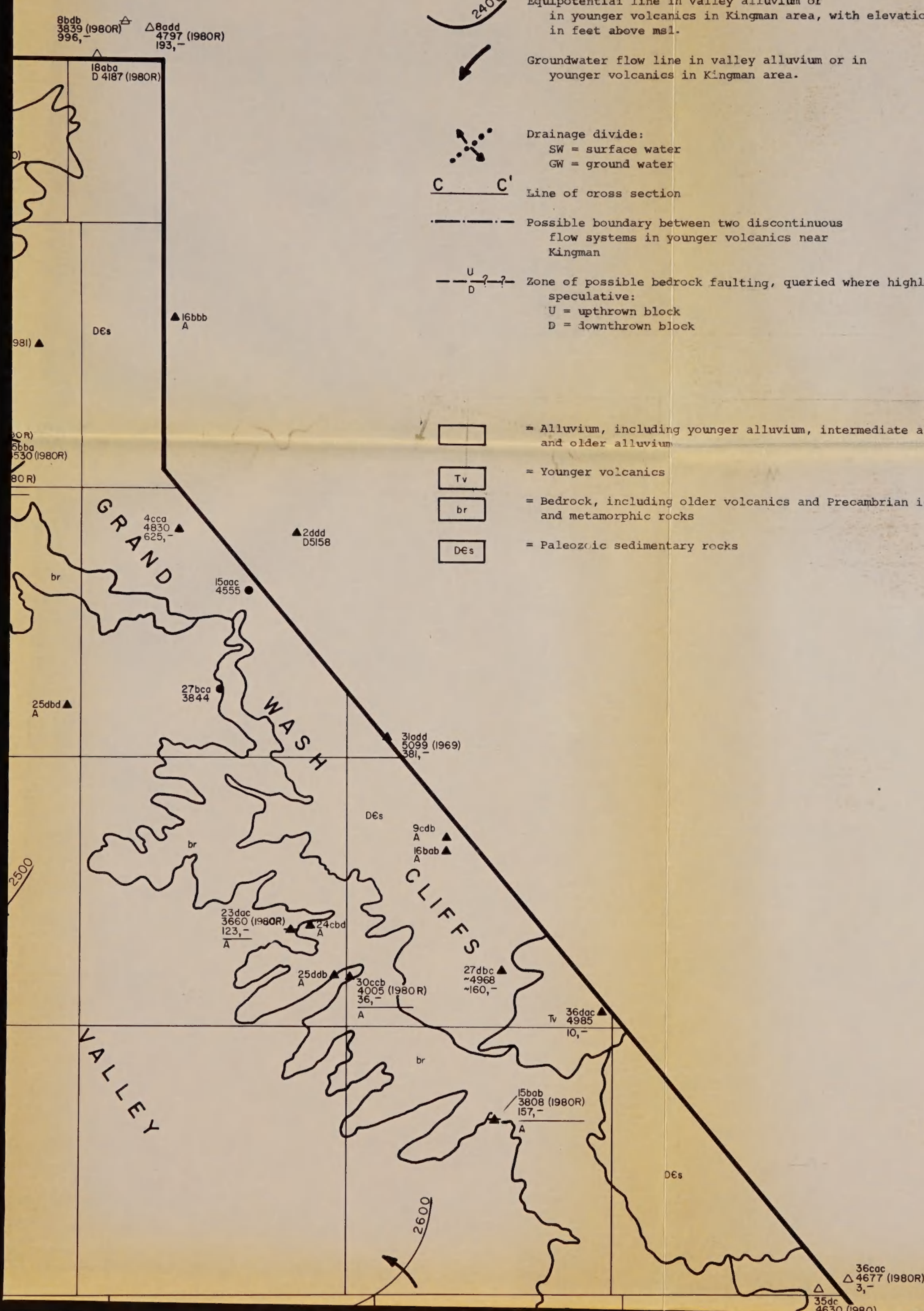
Drainage divide:
SW = surface water
GW = ground water

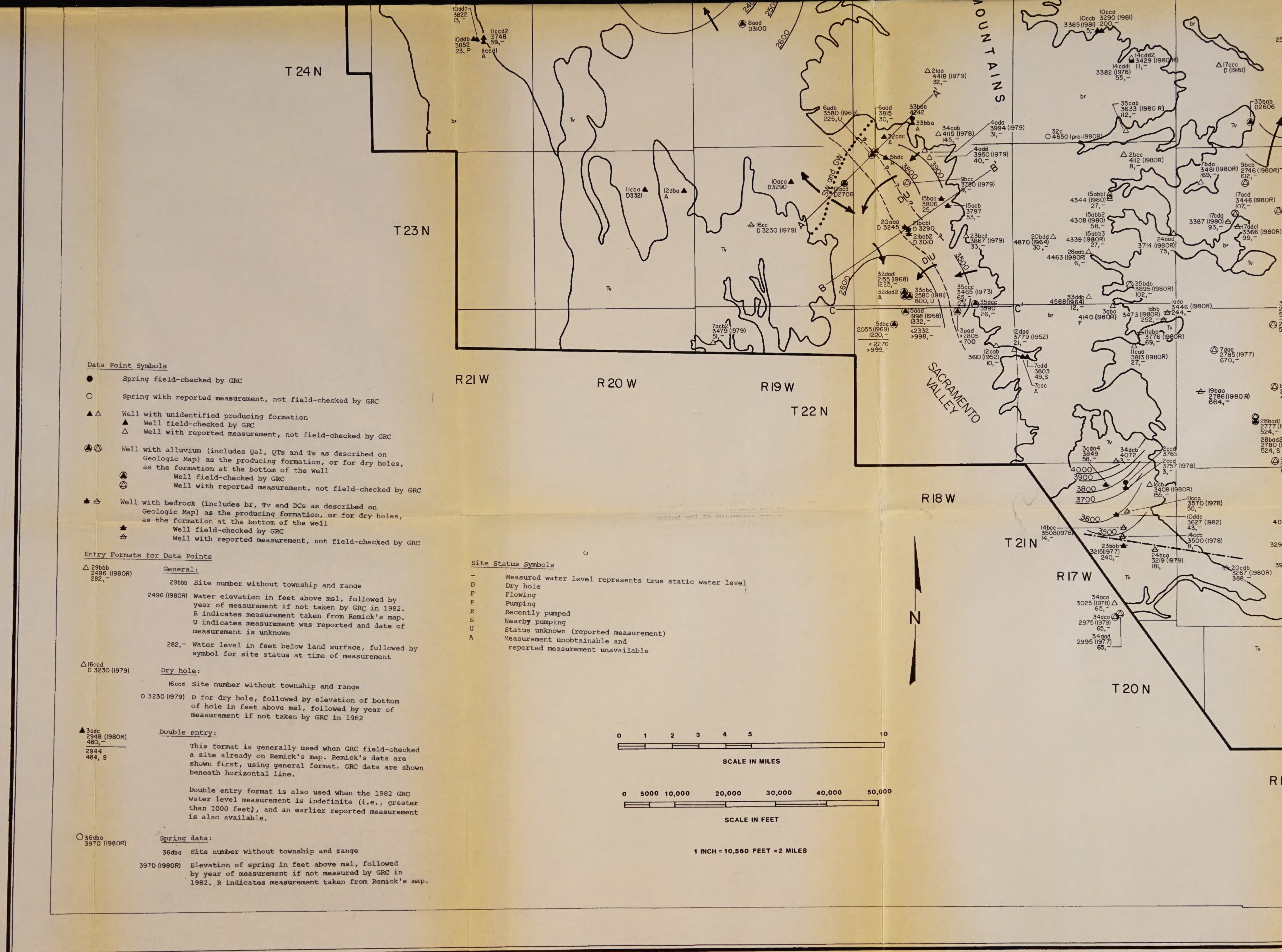
C — C' Line of cross section

Possible boundary between two discontinuous flow systems in younger volcanics near Kingman

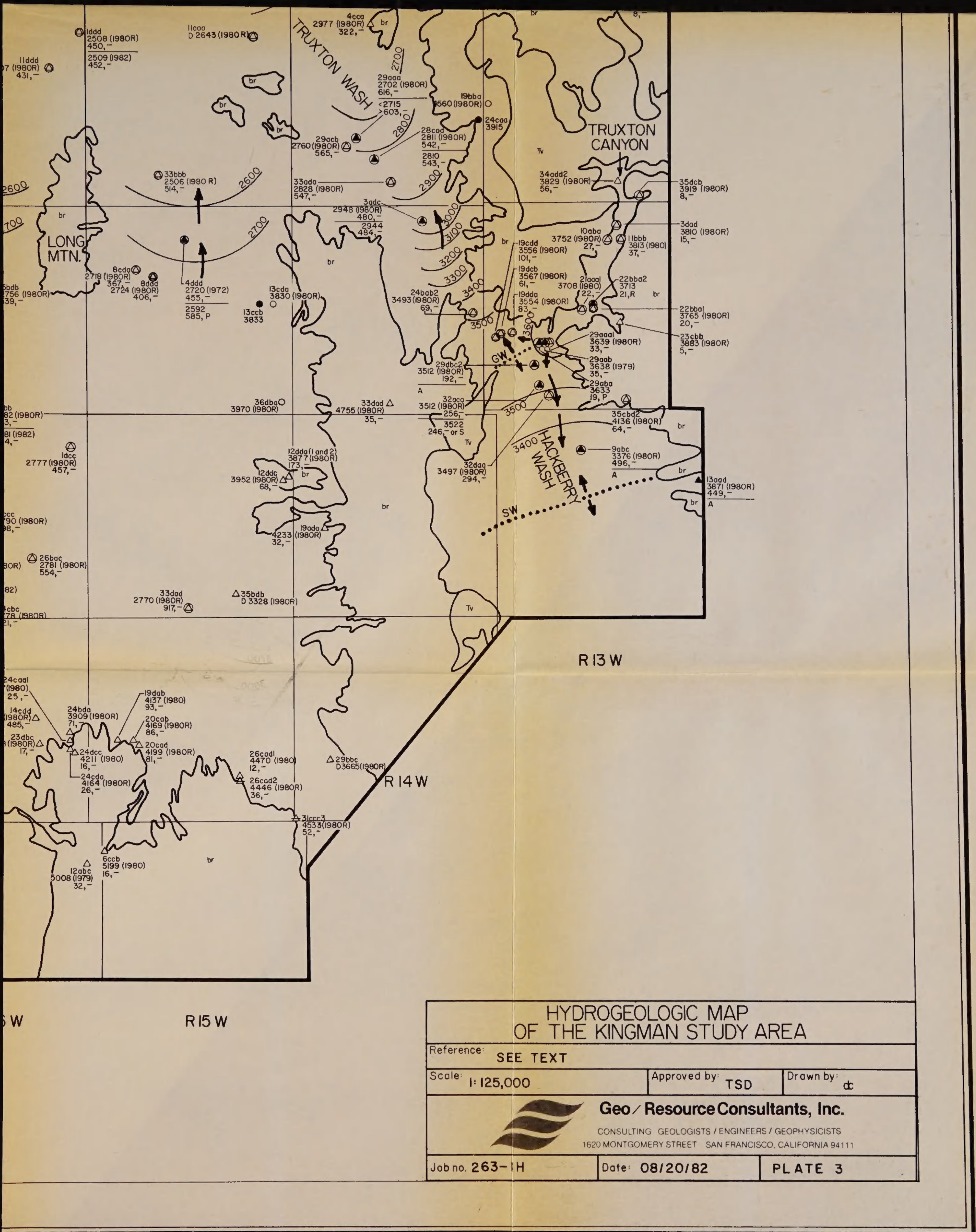
U/D ?—? Zone of possible bedrock faulting, queried where highly speculative:
U = upthrown block
D = downthrown block

(blank box)	= Alluvium, including younger alluvium, intermediate alluvium, and older alluvium
Tv	= Younger volcanics
br	= Bedrock, including older volcanics and Precambrian igneous and metamorphic rocks
D€s	= Paleozoic sedimentary rocks





T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
R 21 W
R 20 W
R 19 W
R 18 W
R 17 W
R 16
MOUNTAINS
SACRAMENTO VALLEY
N
Data Point Symbols
Spring field-checked by GRC
Spring with reported measurement, not field-checked by GRC
Well with unidentified producing formation
Well field-checked by GRC
Well with reported measurement, not field-checked by GRC
Well with alluvium (includes Qal, QTs and Ts as described on Geologic Map) as the producing formation, or for dry holes, as the formation at the bottom of the well
Well field-checked by GRC
Well with reported measurement, not field-checked by GRC
Well with bedrock (includes br, Tv and DCs as described on Geologic Map) as the producing formation, or for dry holes, as the formation at the bottom of the well
Well field-checked by GRC
Well with reported measurement, not field-checked by GRC
Entry Formats for Data Points
29bbb
2496 (1980R)
282,-
General:
29bbb Site number without township and range
2496 (1980R) Water elevation in feet above msl, followed by year of measurement if not taken by GRC in 1982. R indicates measurement taken from Remick's map. U indicates measurement was reported and date of measurement is unknown
282,- Water level in feet below land surface, followed by symbol for site status at time of measurement
16ccd
D 3230 (1979)
Dry hole:
16ccd Site number without township and range
D 3230 (1979) D for dry hole, followed by elevation of bottom of hole in feet above msl, followed by year of measurement if not taken by GRC in 1982
3adc
2948 (1980R)
480,-
2944
484, S
Double entry:
This format is generally used when GRC field-checked a site already on Remick's map. Remick's data are shown first, using general format. GRC data are shown beneath horizontal line.
Double entry format is also used when the 1982 GRC water level measurement is indefinite (i.e., greater than 1000 feet), and an earlier reported measurement is also available.
36dba
3970 (1980R)
Spring data:
36dba Site number without township and range
3970 (1980R) Elevation of spring in feet above msl, followed by year of measurement if not measured by GRC in 1982. R indicates measurement taken from Remick's map.
Site Status Symbols
- Measured water level represents true static water level
D Dry hole
F Flowing
P Pumping
R Recently pumped
S Nearby pumping
U Status unknown (reported measurement)
A Measurement unobtainable and reported measurement unavailable
0 1 2 3 4 5 10
SCALE IN MILES
0 5000 10,000 20,000 30,000 40,000 50,000
SCALE IN FEET
1 INCH = 10,560 FEET = 2 MILES



HYDROGEOLOGIC MAP OF THE KINGMAN STUDY AREA

Reference: SEE TEXT		
Scale: 1:125,000	Approved by: TSD	Drawn by: dc
Geo / Resource Consultants, Inc. CONSULTING GEOLOGISTS / ENGINEERS / GEOPHYSICISTS 1620 MONTGOMERY STREET SAN FRANCISCO, CALIFORNIA 94111		
Job no. 263-1H	Date: 08/20/82	PLATE 3